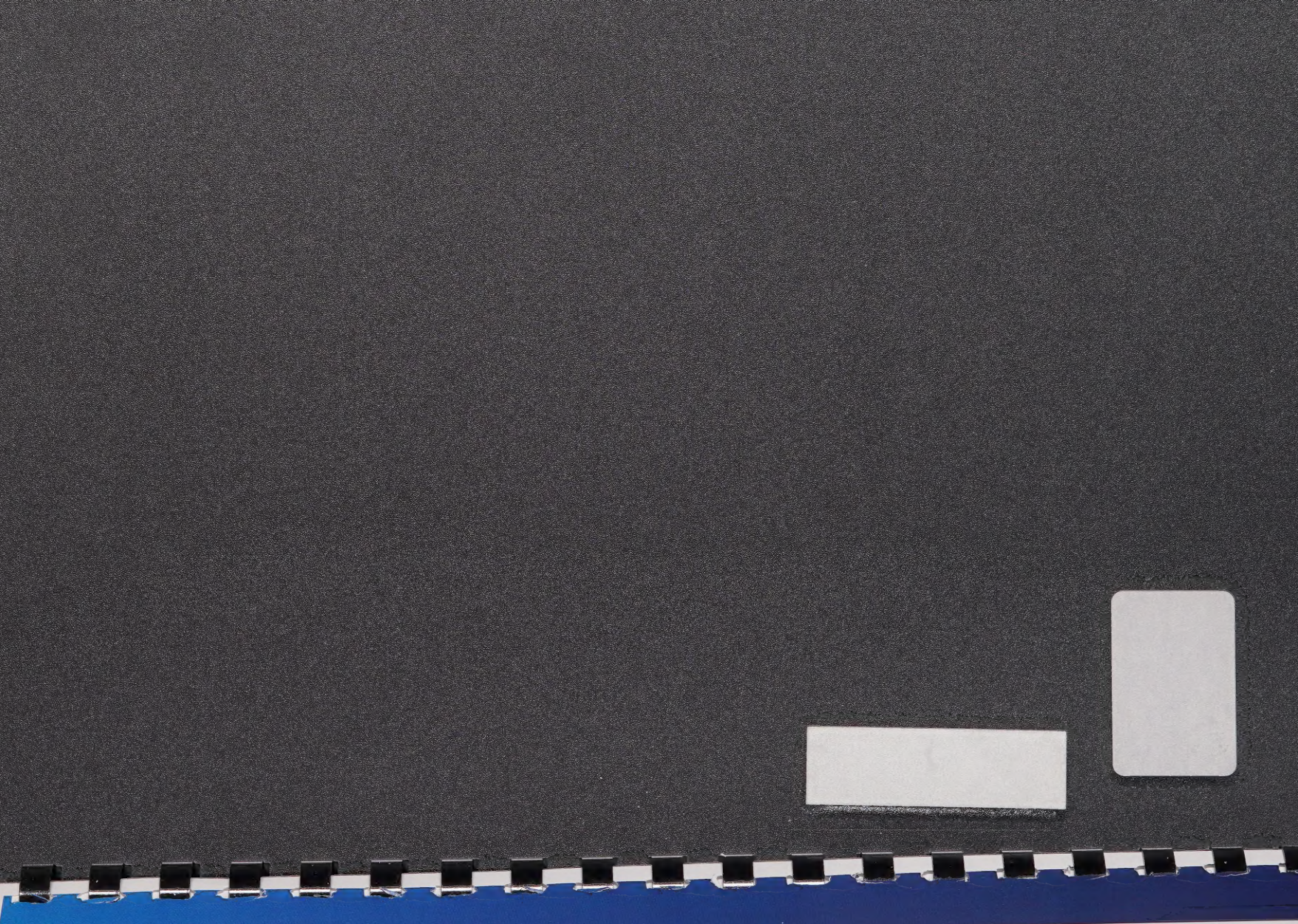
# Fifth National Communication on Climate Change

Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change

2010

Submitted to the UNFCCC Secretariat on February 12th, 2010



Government of Canada Gouvernement du Canada

Canada

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# Executive Summary

## 1.1 Climate Change

The Earth's temperature is determined in part by a naturally occurring heat-retaining process known as the "greenhouse effect". Without this natural process, the Earth's average temperature would be -18 °C instead of the current 15 °C. The greenhouse effect depends on a number of "greenhouse gases" (GHGs) that are present in the atmosphere: water vapour, carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), ozone ($O_3$), sulphur hexafluoride ($SF_6$), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and chlorofluorocarbons (CFCs). GHGs trap the sun's heat near the Earth's surface, raising the Earth's temperature and making life on Earth possible.

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." While certain GHGs are naturally occurring, human activities – primarily those that use energy, but also global deforestation and agricultural activities – release additional GHGs into the atmosphere. Of these anthropogenic (human-induced) GHGs, three are of primary concern, as they represent the major human contribution to climate change:

- Carbon dioxide ($CO_2$): An increasing amount of carbon dioxide is released by the burning of fossil fuels (coal, oil, natural gas) for industrial purposes, transportation, and the heating/cooling of buildings. Deforestation, which involves the permanent removal of forest, also results in greenhouse gas emissions – forest harvesting as part of sustainable forest management is not considered deforestation.
- Methane ($CH_4$): An increasing amount of methane is released by landfills, wastewater treatment, solid waste incineration, certain agricultural practices, and grazing cattle.
- Nitrous oxide ($N_2O$): An increasing amount of nitrous oxide is released into the atmosphere through practices such as the use of chemical fertilizers and the burning of fossil fuels.

The scientific consensus, as reflected by the Intergovernmental Panel on Climate Change (IPCC), is that incremental GHG emissions caused by human activity since the Industrial Revolution are having a discernible impact on the climate. In the IPCC's view, while human activity may cause only about 5% of global GHGs (with natural processes accounting for the remainder), it is enough to upset the delicate balance of GHGs in the atmosphere and, by extension, the climate. The result is the continued warming of the atmosphere and resulting changes in its composition.

Working Group I of the IPCC reports in its Fourth Assessment Report on Climate Change (IPCC, 2007) that the globally averaged temperature is projected to increase by 1.4 °C to 5.8 °C over the period 1990–2100. In Canada, a warming trend of about +1.4 °C has been identified over the last 60 years (Figure 1.1).

While the earth has gone through warming and cooling cycles in the past, the current rate of climate change is more rapid than what the earth normally experiences. It is expected to have significant effects on plants, animals and entire ecosystems that are unable to adapt quickly enough. Canada's Arctic is believed to be particularly vulnerable. The effects of climate change will not be uniform, and the north's climate may rise by nearly 3 °C to 4 °C in winter months over the next 50 years. This could lead to melting glaciers and sea ice, rising sea levels, and endangered wildlife. The north provides an early indication of the environmental, social and economic significance of global warming.

## 1.2 Commitments Under the UNFCCC

In December 1992, Canada ratified the UNFCCC, which entered into force on March 21, 1994. Under the UNFCCC, Canada is committed to:

- adopt measures to mitigate climate change by addressing anthropogenic emissions by sources, and removals by sinks, of all GHGs;
- regularly publish and update reports on these mitigation measures;
- formulate measures to facilitate adequate adaptation to climate change;
- promote and cooperate in the development and transfer of technologies and practices to control, reduce, or prevent anthropogenic GHG emissions;

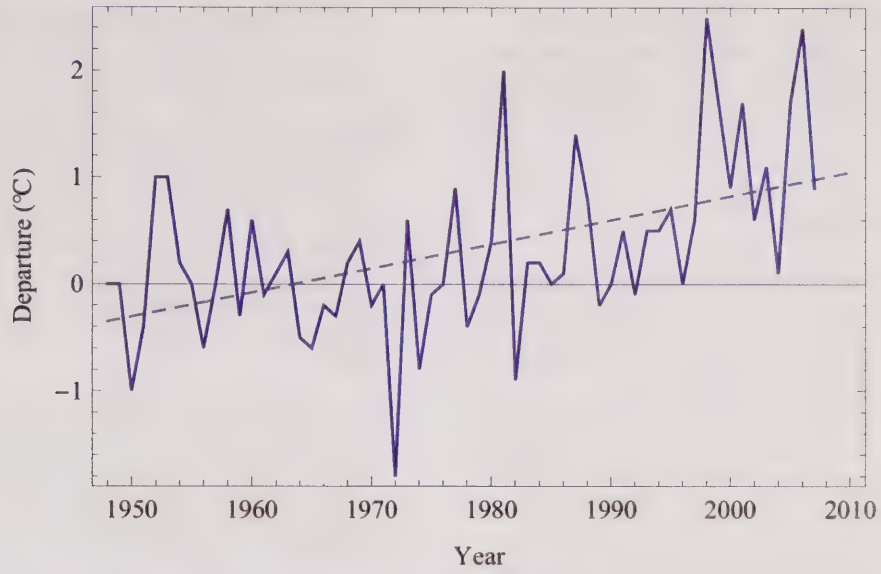


Figure 1.1: Annual Canadian temperature departures trend 1948-2007 – Source: Environment Canada (2007)

- promote sustainable development approaches (e.g. promote the conservation and enhancement of sinks and reservoirs of all GHGs, and take into account climate change in economic and environmental decision making);
- promote and cooperate in the exchange of scientific, technological, and socio-economic information related to climate change, by working nationally on data collection, research, and systematic observation to further understanding of climate change;
- provide new and additional financial resources to help developing countries comply with their obligations under the UNFCCC;
- promote, facilitate, and finance the transfer of environmentally sound technologies to developing countries, enabling them to implement the provisions of the Convention; and,
- collaborate with other countries to ensure that the policy instruments they use to reduce climate change complement, rather than counteract, measures taken elsewhere.

A subset of the Parties to the UNFCCC agreed to a supplementary international treaty, the Kyoto Protocol, which has stricter demands for reducing GHG emissions and more powerful, legally-binding measures for Annex I countries.

The Kyoto Protocol was negotiated at the Third Conference of the Parties to the UNFCCC (CoP3) in December 1997. The Kyoto Protocol was signed by Canada in April 1998, and formally ratified by the Government of Canada (GoC) in December 2002. On February 16, 2005, a sufficient number of countries had ratified the Kyoto Protocol for it to enter into force. The Protocol is based on binding GHG emissions targets for industrialized countries at between -8% and +10% of the countries' individual 1990 emissions levels, "with a view to reducing their overall emissions of such gases by at least 5% below existing 1990 levels in the commitment period 2008 to 2012." Canada committed to reduce GHG emissions to 6% below 1990 levels during the commitment period[1].

## 1.3 National Reporting to the UNFCCC

This communication describes the progress Canada has made in implementing its commitments under the UNFCCC and the Kyoto Protocol in supporting actions in

[1]The Kyoto Protocol covers only those GHGs that are not already controlled by the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, which covers chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform. The GHGs covered under Kyoto are carbon dioxide, methane, nitrous oxide, HFCs, PFCs, and sulphur hexafluoride.

Canada and internationally to address climate change. It provides an update of Canadian circumstances and policies and measures from 2006 (the end of the period covered by the Fourth National Communication) up to April 2009.

## 1.4 Summary

Canada's 2007 GHG emissions from all sources, excluding LULUCF, were 747 Mt of $CO_2$ eq, a 26% increase from 1990 levels of 592 Mt. This growth in emissions can be attributed to a number of factors, including economic and population growth.

The Canadian economy grew by almost 60% from 1990 to 2007. However, the GHG intensity of Canada's economy has progressively decreased, particularly since 1996. As a result, in 2007, the GHG intensity of Canada's economy was 21% lower than in 1990.

Canada's national population also grew by 18% between 1990 and 2007, largely through immigration. This is about three and a half times more growth than the average among France, Germany, Italy, Japan and the UK. Canada's population is projected to increase by a further 10% to reach 36.4 million by 2020.

Canada is committed to tackling climate change through sustained action to build a low-carbon economy. Throughout the 2006 to 2009 period, Canada took action internationally, continentally and domestically.

Internationally, Canada worked towards a new, fair, comprehensive and effective legally binding agreement for the post-2012 period. Canada supported mitigation efforts in other countries through capacity building and technology transfer and partnership initiatives. Canada also provided considerable financial and other support to strengthen the capacity of the poorest and most vulnerable to adapt to the impacts of a changing climate.

Continentally, Canada worked with our North American partners towards effective regional action, including the development of a continental cap and trade scheme.

Domestically, Canada implemented a suite of policies and measures to address its GHG emissions. In addition to various measures implemented by Canada's provinces and territories, the national policies and measures described in this report include:

- Clean electricity: Canada has set a national goal of producing 90% of its electricity needs without emitting GHGs by 2020. Achieving this goal will require increased energy efficiency, fuel-switching away from coal, and expanded use of nuclear and renewable power such as hydro and wind. Governments in Canada are providing significant incentives to increase Canada's supply of clean electricity from renewable sources.

- Energy efficiency: Canada is amending energy efficiency regulations under the Energy Efficiency Act to introduce new performance standards on products accounting for 80% of the energy used in homes and businesses in Canada. Governments in Canada are also implementing a wide range of energy efficiency programs for consumers and businesses, and exploring the potential of smart grids.

- Carbon Capture and Storage: in addition to regulatory measures that will promote implementation of carbon capture and storage, Governments in Canada are investing over $3 billion to support the development, demonstration and deployment of commercial-scale CCS between now and 2015.

- Vehicle emissions: new national regulatory tailpipe GHG emission standards for new cars and light trucks will reduce average fuel consumption and $CO_2$ emissions from new vehicles of the 2016 model year by 20%. These standards will be phased-in beginning with the 2011 model year and will be aligned with U.S. national standards.

- Renewable fuels: national renewable fuels standard will require an average annual renewable fuel content of at least 5%, effective in 2010, and an average 2% renewable fuel content in diesel fuel and heating oil by 2011 or earlier, subject to technical feasibility. Canada is also investing $500 million to support the establishment of commercial scale demonstration facilities for the production of next-generation renewable fuels.

Since 2006, Canada has also been developing a comprehensive, market-based regulatory regime for GHG emissions from major industrial sources. In 2009 Canada indicated it would review this proposed regime to align with the emerging cap and trade program in the United States. Aligning our climate change policies and measures with those of the US is a critical element of Canada's overall approach, in light of the close integration of our two economies and our geographic proximity.

As this cap and trade regime was not finalized during the 2006 to April 2009 period covered by this report, Chapter 4 does not describe it. Similarly, the emissions projections in Chapter 5 do not account for it.

## 1.5 Related Documents

Chapter 3 of this communication is a summary of the National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990-2007. http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm

In addition, Canada's Greenhouse Gas Emissions: Understanding the Trends, 1990-2006 is a companion document to the National Inventory Report. It provides additional analysis on the underlying trends that have shaped Canada's total greenhouse gas emissions since 1990.

## References

Environment Canada. 2009. Canada's National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990-2007.
http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm

Environment Canada. 2008. Canada's Greenhouse Gas Emissions: Understanding the Trends, 1990-2006.
http://www.ec.gc.ca/pdb/ghg/inventory_report/2008_trends/trends_eng.cfm

IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

# Chapter 2

# National Circumstances

## 2.1 Introduction

In periodic submissions to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), Canada and other countries are given an opportunity to outline National Circumstances within the country that give rise to observed trends in greenhouse gas emissions.

A national circumstance can be defined as a relatively static characteristic of a nation, not easily malleable by government policy, which has a significant influence on potential greenhouse gas emission levels and which would impact on the design of government mitigation policies.

The following factors influence Canada's overall emissions profile:

- *The effect of climate on the commercial and residential sectors.* Compared to many industrialized countries, Canada has an extreme climate, characterized by long, cold winters. This contributes to higher energy use for space heating in both the commercial and residential sectors compared to other industrialized countries with more moderate climates. That said, residential emissions were essentially the same in 2007 as they were in 1990, despite population growth. This can be attributed to improved energy efficiency standards and a significant share of overall power generation from renewable, nuclear and hydro sources.

- *The effect of geography and population distribution on the transportation sector.* Relative to most other industrialized countries, Canada has a large landmass, combined with a very low overall population density. These factors contribute to a higher energy demand for freight transportation than in smaller and/or more densely populated countries. The majority of emissions related to fossil fuel use in Canada comes from vehicle use.

- *A large, export orientated fossil fuel processing sector.* Canada is relatively unique amongst OECD countries in that it is a net exporter of energy, with large reserves of conventional oil and gas as well as oil sands. A significant and increasing share of Canada's energy production is exported. From 1990 to 2007, Canada's oil and gas exports increased by 181%. In 2007, Canada's net export of total energy was 36% of total production. Between 1990 and 2007, increased oil and gas production, in response to particularly strong global demand for energy, was a significant contributor to the rise in Canada's emissions.

- *An energy intense industrial structure.* A large part of economic activity in Canada relates to the production of raw material and processed goods, which are energy intensive activities. That said, a large portion of Canada's overall energy intensity improvements from 1990-2007 were due to end-use energy efficiency gains in the industrial and manufacturing sectors. The energy intensity of the Canadian manufacturing sector decreased by 28% in this time period, compared to an average improvement of 22% among IEA countries.

- *Faster than G7 average population growth.* Canada's population grew by 19.1% between 1990 and 2007, largely through immigration. This was the sixth largest rate of growth among developed countries. Canada's population growth is expected to increase by a further 10% to reach 37 million by 2020.

The remainder of this section presents more detailed analyses on the national circumstances outlined above, relative to other G7 countries. Findings for the population and fossil fuel decompositions are up to 2006, whereas all other sectors are updated to 2005.

## 2.2 Methodology for Analyzing Canada's National Circumstances

The national circumstances analyzed in this section are: climate, geography, industrial structure, and fossil fuel production for export. The first three are analyzed using decomposition analysis, explained in Section 2.2.1. The method for analyzing fossil fuel production for export is explained in Section 2.2.2. The method for analyzing the effect of faster-than-average population growth is explained in Section 2.2.3.

### 2.2.1 Decomposition analysis – climate, geography, and structure

Decomposition analysis is often applied in order to understand changes over time in a country's energy consumption or $CO_2$ emissions. The annual Natural Resources Canada publication Energy Efficiency Trends in Canada , for example, conducts a decomposition analysis to determine factors that have influenced changes in energy consumption in Canada over time, both at the economy-wide level and at the sectoral level. Similar efforts are undertaken by many other countries and for groups of countries.[1][2]

More recently, and to lesser extent, decomposition analysis has been applied in order to understand differences in energy consumption or $CO_2$ emissions between countries or groups of countries at a single point in time. The decomposition analysis used in this chapter breaks the difference in per capita $CO_2$ emissions between countries into the following terms:

**Activity** - this term captures the difference in $CO_2$ per capita that is caused by differences in overall activity between countries. Activity refers to the overall output of the sector (for example, per capita gross value added in the industrial sector, and per capita tonne-kilometres travelled in the freight transportation sector).

**Structure** - this term captures the difference in $CO_2$ per capita that is caused by differences in structure between countries. Most sectors analyzed can be further disaggregated into sub-sectors, which have different characteristics. For example, the industry sector consists of several subsectors with different energy intensities. If the industrial structure in one country is dominated by $CO_2$ intensive subsectors, while in another country it is dominated by non-$CO_2$ intensive sectors, the structure term will help explain the overall difference in $CO_2$ intensity between the two sectors.

**Energy intensity** - this term captures the difference in $CO_2$ per capita that is caused by differences in energy intensity between countries. Energy intensity is measured in units of energy consumed per unit of activity delivered.

**Fuel mix** - this term captures the difference in $CO_2$ per capita that is caused by differences in fuel mix between countries. Because different fuels emit different amounts of $CO_2$ per unit of energy delivered, the fuel mix can be important in accounting for differences in total $CO_2$ emissions between countries.

**Carbon emissions factor** - this term captures the difference in $CO_2$ per capita that is caused by different carbon factors between countries. While the fuel mix term captures the differences in types of fuels used, the carbon emission factor term captures differences in carbon emissions for the same type of fuel between countries. This term is mainly accounts for differences in the electricity generation sectors (and the public heat sector) of different countries, since fossil fuel carbon emissions factors do not differ significantly between countries.

**Climate** - The main difference between the commercial and residential sectors and the rest of the economy is their sensitivity to climate, specifically in the form of space heating requirements; colder countries require more energy for space heating.[3] To accommodate this and make comparisons between countries of different climates useful, energy analysts commonly add an additional climate factor to decomposition analyses to evaluate how much of the space heating energy consumption is a result of its climate.

**Geography and Population Distribution** - In a similar manner, the geography and population distribution of a country can significantly influence its demand for travel in the freight and passenger transportation sectors. In order to enable comparisons between countries of different geographies, we added an additional factor to the decomposition analyses in the freight and passenger transportation sectors to capture the degree to which demand for travel is influenced by geography.

In the decomposition analysis, when a comparison is made between a country and the group average, that country's own share in the average is omitted. This prevents large countries like the US and Japan from overwhelming the averages to which they are compared. This report refers to the attributes of one country and

[1] See International Energy Agency. 2004. "30 Years of Energy Use in IEA Countries: Oil Crises and Climate Challenges". Organization for Economic Cooperation and Development: Paris.

[2] See also Environment Department, World Bank 2007. "Growth and $CO_2$ Emissions: How do Different Countries Fare"

[3] Space cooling plays an important and growing role, but its current energy use is several orders of magnitude smaller than space heating worldwide.

the "others' average" - the average attributes of the group of G7 countries excluding the country being analyzed. For example, in the transportation decomposition analysis, transportation in each country is compared to the average of all other countries. For Canada, the average group excludes Canada, so the comparison group is a weighted average of the US, the European countries, and Japan, with the US and aggregate European countries exerting a strong pull on the average because of their sizes. For the US, the average group is a weighted average of Canada, the European countries, and Japan. In this case, the European countries dominate the weighted average. As a result, the comparison group can have significantly different characteristics for different countries - there is not a consistent baseline for the decomposition analysis when analyzing different countries.

### 2.2.2 Embodied emissions analysis – fossil fuel production

As it is currently practised, production of fossil fuels is a greenhouse gas intensive activity, so countries that are net exporters of fossil fuel products may have a correspondingly higher greenhouse gas emissions intensity as opposed to those that are net importers. One fifth of Canada's greenhouse gas emissions are from fossil fuel production, a share that continues to grow, and roughly half of Canada's fossil fuel production is for export.

If all G7 countries were self-sufficient in fossil fuels, the emissions intensities of countries would likely be closer. Likewise, if emissions from production of fossil fuels were accounted for in the country in which they were consumed, emissions intensities of fossil fuel exporting and importing nations would converge. This section describes a methodology for allocating emissions associated with fossil fuel production to the country in which they are consumed. Unlike previous sections, the methodology reported here does not follow a decomposition approach.

In order to allocate emissions associated with the production of fossil fuels to the country in which they are consumed, for each country it is necessary to add the emissions associated with the upstream production and international transportation of imported crude oil, natural gas and coal, and subtract the production emissions associated with exports. Equation 2.1 provides a general model for these calculations.

$$GHG_{Normalized} = GHG_{Base} + \sum_{J} M_j.I_j - \sum_{J} X_j.I_j \quad (2.1)$$

The subscript $j$ is an index of fossil fuels (natural gas, coal, crude oil), M refers to imports, X to exports, and I to the emissions intensity of fossil fuel $j$. $j$ for crude oil is specific to each pair of importing and exporting countries to accommodate the mix of crude oil types and international transportation. For example, the production of heavy crude oil is much more greenhouse gas intense than light crude oil because of its characteristic extra fugitive emissions, while Norwegian upstream production of crude oil is less greenhouse gas intense than that from any other source, mainly because it comes from offshore platforms, where fugitive emissions must be strictly controlled because of the fire hazard. A global $j$ is used for natural gas and coal based on Canada's intensities.

### 2.2.3 The effect of population growth on emissions

Canada and the US experienced significantly faster population growth than the rest of the G7 in the 1990-2006 period, which has significantly affected their growth in $CO_2$ emissions compared to the other G7 countries. The effect of population growth from 1990-2006 on total emissions by calculating what each country's emissions would have been at the end of 2006 if they had grown by the weighted average G7 population growth rate. For the purposes of this chapter, this calculation is carried out using both the countries' actual and population-weighted G7 average $CO_2$ intensities.

## 2.3 Climate and $CO_2$ Intensity in the Residential Sector

Canada has one of the coldest climates of any country, shared only by the Scandinavian countries and Russia, and the coldest climate in the G7 by a significant margin. As measured by population-weighted heating degree days (based on differences from an average temperature of 18 °C), Canadian residences experience much cooler weather than the rest of the G7.[4] Canada experiences 48% more heating degree days than the G7 average, and residences in Canada consume 53% of their energy for space heating. Conversely, Canada experiences nearly 60% less cooling degree days, and only 2% of residential energy is spent on space cooling. While space cooling plays a growing role, its current energy use is several orders of magnitude smaller than space heating worldwide. The colder a country is, the larger its space heating requirements are likely to be, and the more effort will likely be put into space heating efficiency. On average, 53% of energy consumption in G7 residences is for space heating.

### 2.3.1 Comparative Statistics

In 2005, Canada's residential sector emitted 2.4 tonnes $CO_2$ per capita, 21% less than the G7 average of 3.04, and 23% less than the average of France, Germany, Italy, Japan and the UK.

Residences in Canada emitted only 59 tonnes of $CO_2$ per TJ of energy consumed, 37.7% less than the G7 average, as shown (figure 2.1). This reflects the hydro and nuclear power used by Canada's electricity sector. Only France, which produces most of its electricity by nuclear power, has a lower carbon intensity of residential energy use.

### 2.3.2 Analysis Summary

Canada's residential $CO_2$ per capita, is close to the G7 average. Decomposition analysis (figure 2.2)shows that this is the result of the offsetting effects of the low $CO_2$ intensity of electricity in Canada and its cold climate. If Canada had an average G7 climate, it's residential sector would emit 0.53 tonnes less $CO_2$ per capita.

## 2.4 Geography in Freight Transportation

The emission intensity of the freight transport sector in G7 countries is heavily influenced by the types of transportation used, the amount of freight shipped, the energy intensity of shipping, and the distance freight is shipped. Intuitively, larger countries with dispersed populations would require that freight be shipped over longer distances than smaller, more densely populated countries. This chapter only addresses domestic freight transport because international transport emissions are not included as part of a country's national greenhouse gas inventory. In addition, due to very limited data availability for the European countries and Japan, pipeline data were excluded despite the fact pipelines can be considered an important part of a nation's freight transport infrastructure, especially in the context of Canada's significant oil and gas sector.

### 2.4.1 Comparative Statistics

Domestically, Canada ships freight farther per capita than any other G7 country. Canada ships 21,219 tonne-kilometres (tkm) per capita; 91% more than the weighted G7 average, and almost 270% more than the average of France, Germany, Italy, Japan, and the UK. This can be seen in figure 2.3.

Energy consumption per capita shows a very similar pattern to shipping rates. Canadian domestic freight

[4] Heating degree days (HDD) for a given nation are normally calculated using the following sequence of formulas:
To calculate annual HDDs for an individual weather station

1. Find the day's average temperature by adding the high and low temperatures then dividing by two.
2. If the number is above 18, there are no heating degree days for that twenty four hour period.
3. If the number is less than 18, subtract it from 18 to find the number of heating degrees.
4. To calculate the annual heating degree days, take a sum of each day's HDDs.

To calculate a national HDD

1. Weight each of the weather station values calculated previously by their region's component of the nation's total population. The sumproduct of these weights by the individual HDDs is the national value.
2. Annual HDDs are often compared to long term trend HDDs (e.g. 1950 to the present), which are averages corrected for changes in population distribution.

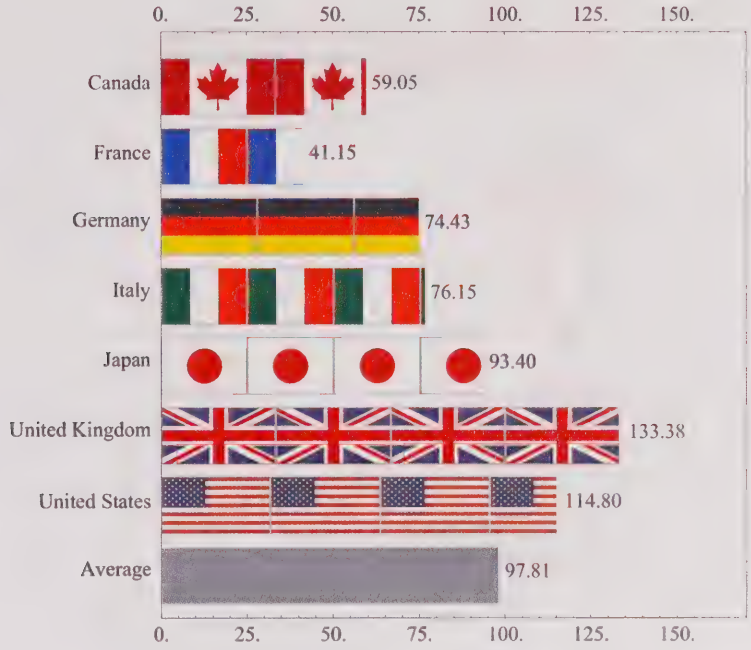


Figure 2.1: Residential sector $CO_2$ intensity of energy consumption (t $CO_2$/ TJ)

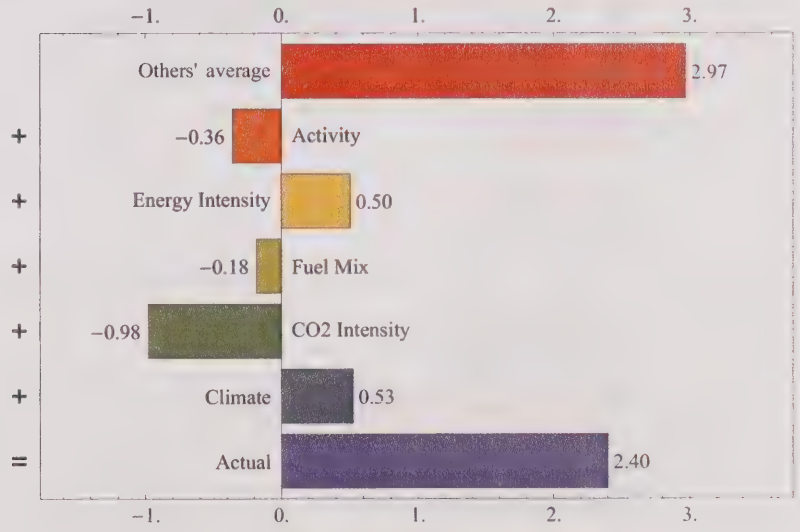


Figure 2.2: Residential sector decomposition results for Canada

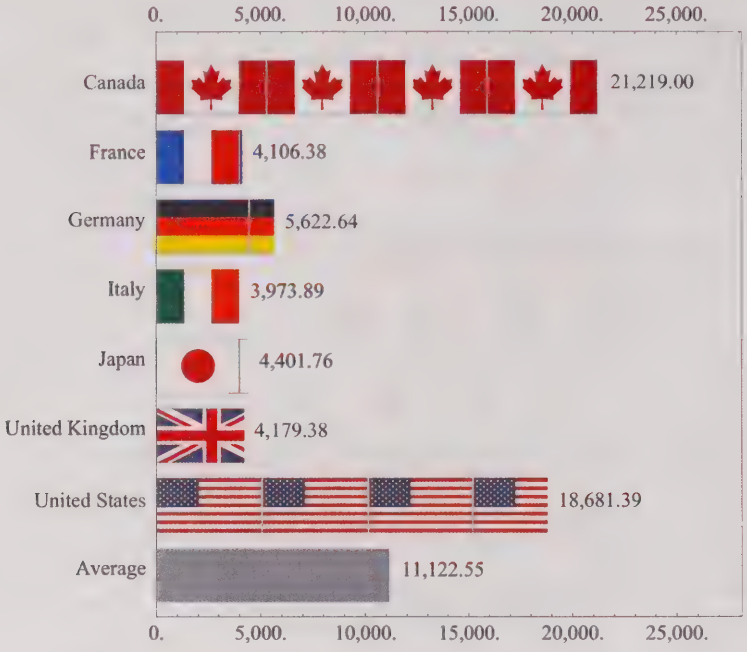


Figure 2.3: Tonne kilometre shipped per capita

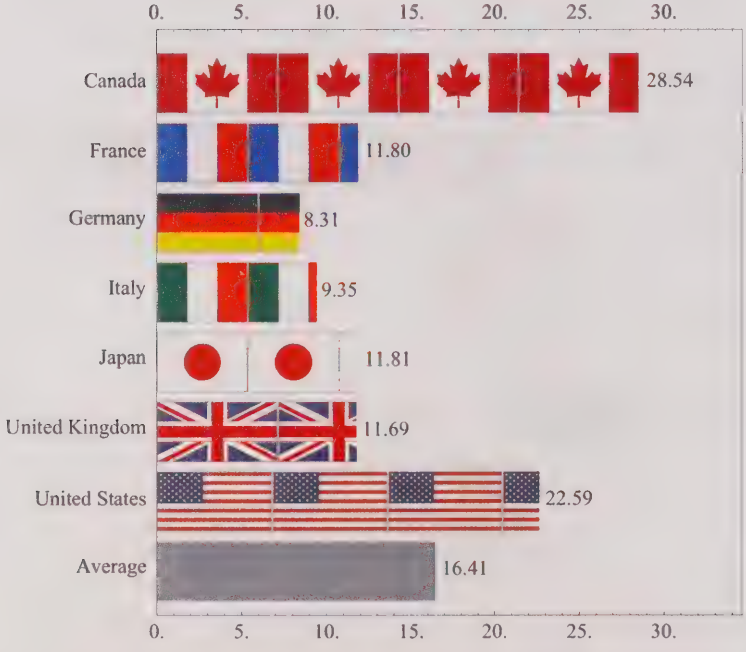


Figure 2.4: Freight transport energy consumption (GJ) per capita

consumes 28.5 GJ per capita, 74% greater than the weighted G7 average, as seen in Figure 2.4.

Canada and the US consume the lowest amount of energy per tonne-kilometre of freight shipped in the G7. Canada's energy intensity of 1,345 GJ per million tonne-kilometres shipped is 8.8% lower than the weighted G7 average of 1,475 GJ per million tonne-kilometres. Excluding the US, Canada's energy intensity drops to 35% lower than the average of the remaining G7 countries, as illustrated by figure 2.5

Since transportation is largely fuelled by fossil fuels, emission intensities follow energy intensities. Canada has the highest emissions per capita of the G7 at 2.02 tonnes $CO_2$ per capita, 77% greater than the weighted G7 average and 143% greater than the average of France, Germany, Italy, Japan and the UK. (Figure 2.6)

The structure of freight transport sectors in G7 countries has a substantial influence on the countries' energy and emission intensities. Significant variation exists among countries. Canada and the US use the lowest proportion of truck transport and the highest proportion of rail. Rail freight transport in particular seems to be correlated with geography - freight shipping distances of a certain minimum size are required before rail becomes economically viable. Italy is the only country that uses almost no marine transport for freight.(Figure 2.7)

### 2.4.2 Analysis Summary

Decomposition analysis shows that the emission intensity of Canada's freight transportation sector is primarily the result of four factors: high activity, high energy intensity, energy efficient structure, and large geography. In particular, the influence of geography on freight transportation results in a 0.22 tonnes per capita difference in $CO_2$ emissions between Canada and other countries. (Figure 2.8)

## 2.5 Structure in the Industrial Sector

Industry is not homogeneous; it produces a wide variety of intermediate and finished products using many different processes. These processes differ widely in their energy requirements and in the value of the products produced. As a result, the energy intensity of different industrial sectors varies tremendously. Direct comparison of the aggregate energy intensity of multiple countries could therefore be misleading if consideration is not taken of differences in countries' industrial structure. A more informative comparison would separate out the effect of structure, thus enabling the comparison of the energy intensity and carbon intensity of specific sectors between countries.

The decomposition analysis for the industrial sector calculates how much of the difference between the $CO_2$ emissions per capita in one country and the average of the others is due to activity (GDP/cap), structure (share of GDP by industrial sub-sector), energy intensity (energy/GDP), fuel mix (share of energy consumption by fuel type), and $CO_2$ intensity ($CO_2$ emissions per unit of energy delivered). In 2005, Canada's industrial sector produced 13.8 tonnes $CO_2$ per capita, which is 44% more than the G7 average. The decomposition analysis shows that the large difference between the $CO_2$/capita of Canada and other countries results almost completely from preponderance of high energy intensity (TJ/$) industry sub-sectors in Canada. The high energy intensity of Canada's industrial sector is driven by two key sectors, the pulp and paper and refining sectors.

## 2.6 Embodied Energy in Production of Fossil Fuels for Export

Most of the world's oil and natural gas production does not occur in the same country the final product is consumed. A few areas with a net surplus (e.g., the Persian Gulf, the former Soviet Union, parts of Africa, Canada and the North Sea) provide most of the world's traded fossil fuels. There are significant $CO_2$ and methane emissions associated with fossil fuel production and processing. Fuel is burned to drive pumps and motors, and to provide process heat in the case of Canada's oil sands industry. Significant amounts of methane are also emitted in the production, processing and transportation of natural gas and crude oil; methane is a greenhouse gas 21 times more potent than $CO_2$.[5] Concentrated sources of methane can be converted to $CO_2$ by combustion flaring, which reduces its greenhouse gas potency, but this $CO_2$ still adds to net emissions levels.

GHG emissions associated with the production of fossil fuels (or any other product) are normally allocated to the country that produces them, not the country that

[5]Until recently, the estimated 100 year global warming potential for methane was 21 times that of $CO_2$. The Third Assessment report of the IPPC indicates 23 may be more correct, but we have used 21 for this study for consistency with Canadian government publications (e.g., Environment Canada GHG Inventory).

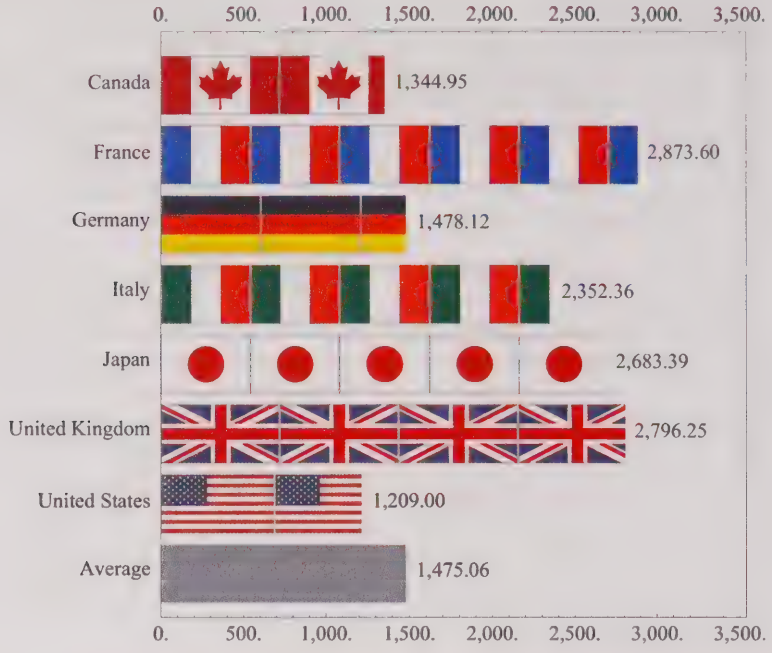


Figure 2.5: Freight transportation energy consumption (GJ) per million tonne-kilometre

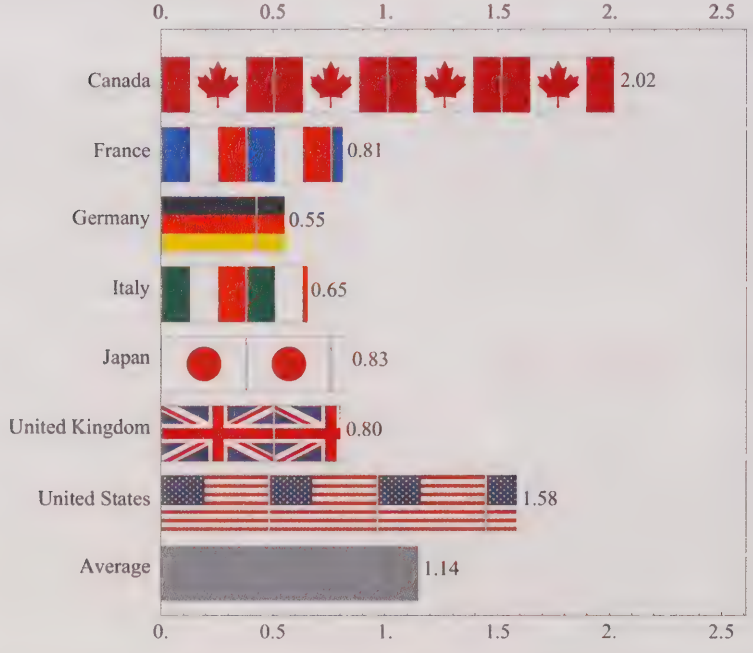


Figure 2.6: Freight transport $CO_2$ emissions per capita

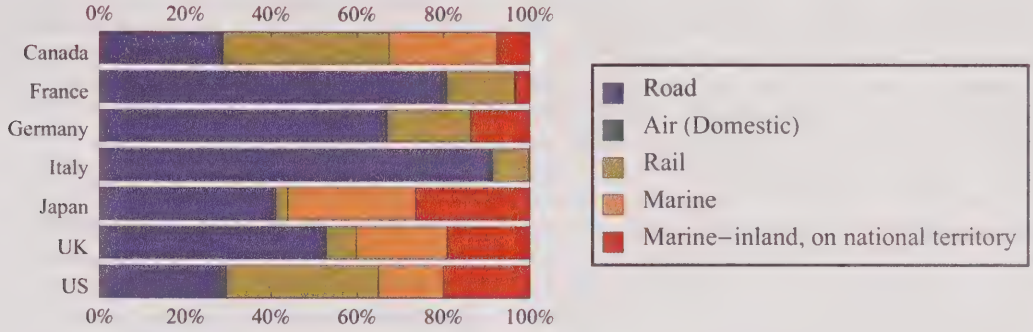


Figure 2.7: Proportions of transportation modes in the freight transportation sector in G7 countries

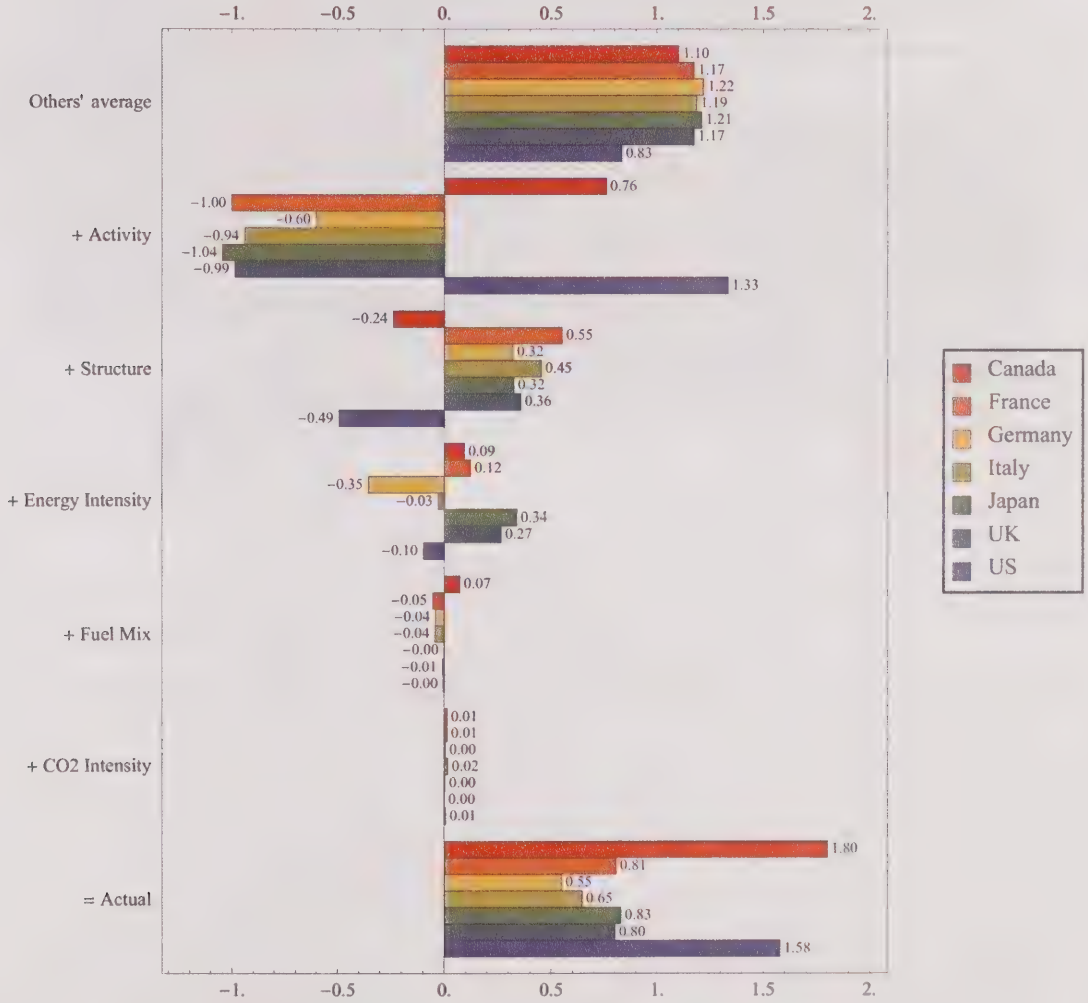


Figure 2.8: Freight transport sector decomposition results for the G7

consumes them. If these emissions were instead allocated to the country where they were consumed, the intensities of many countries would be very different.

Canada and the UK are the only G7 countries that have significant fossil fuel exports. As figure 2.9 illustrates, Canada exports nearly half of all the fossil fuels it produces, mainly GHG intense products such as synthetic crude oil. If all countries were self-sufficient in fossil fuels, Canada would emit 2.17 tonnes of GHGs per capita less, while all other countries would emit more. Canada's emissions would be 2.97 tonnes per capita lower than if it had the same pattern of exports and imports as the rest of the G7.

## 2.7 The Effect of Faster than G7 Average Population Growth

### 2.7.1 Comparative Statistics

Each country's total $CO_2$ emissions can be calculated as the product of its emissions per capita times its population. Even with improving emissions intensity, emissions could still rise as a result of population growth. Since 1990, the populations of North American countries versus those of Europe and Japan have followed two distinctly different growth paths; the population of the US and Canada rose by 18.2 and 16.5% respectively, while all the other G7 countries' populations grew by 8.5% or less, as illustrated by figure 2.10. Immigration accounts for the bulk of the difference in growth rates.

### 2.7.2 Analysis Summary

To quantitatively address the relative effect of population growth on the G7, this report compares each country's actual growth rate to an average growth rate weighted by population. Canada's population growth rate from 1990-2006 is 6.61% more than the average. (Figure 2.11)

Estimating the national circumstances associated with faster than average population growth opens a methodological question. When the average G7 country adds a person to its population its emissions increase by 13.2 tonnes of $CO_2$; when Canada adds a person its emissions increase by 16.5 tonnes. As the previous sections in this chapter illustrate, that difference is partly due to national circumstances such as climate and geography. If the weighted average G7 $CO_2$ intensity is used instead of Canada's actual intensity for the 1990-2006 period, then Canada's $CO_2$ emissions in 2006 would have been lower by 24.24 Mt instead of 30.28 Mt $CO_2$.(Figure 2.12)

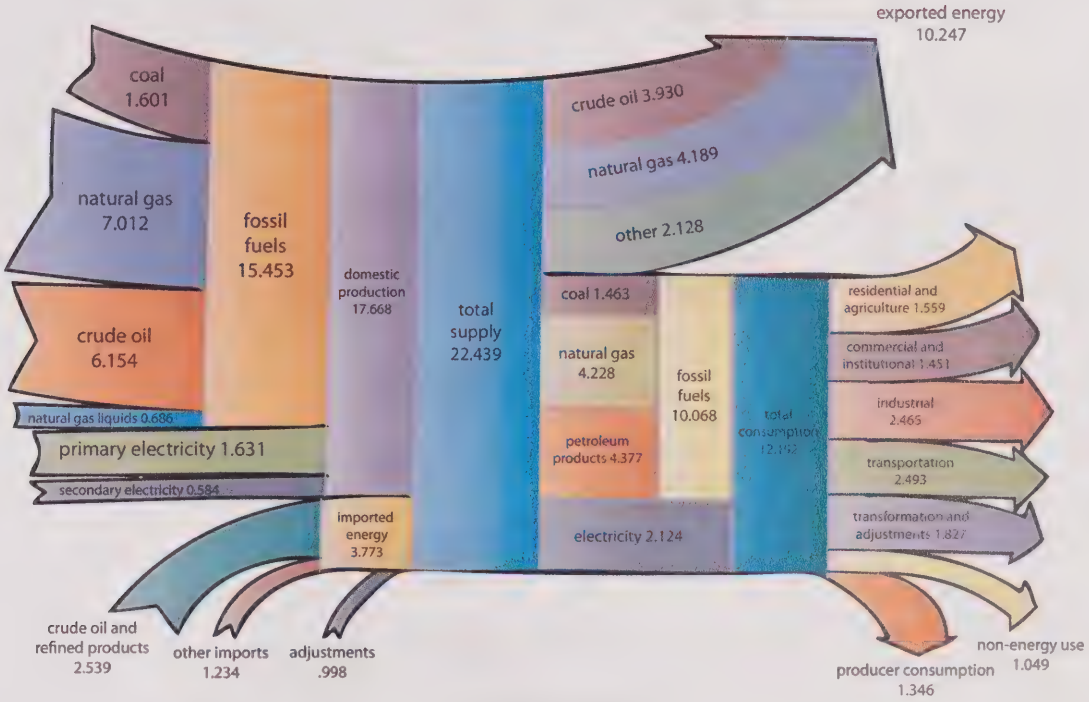


Figure 2.9: Energy Flow (in petajoules) 2007

Source: Statistics Canada. Report on Energy Supply and Demand in Canada, 2007. Catalogue no. 57-003-X. February 20, 2009.

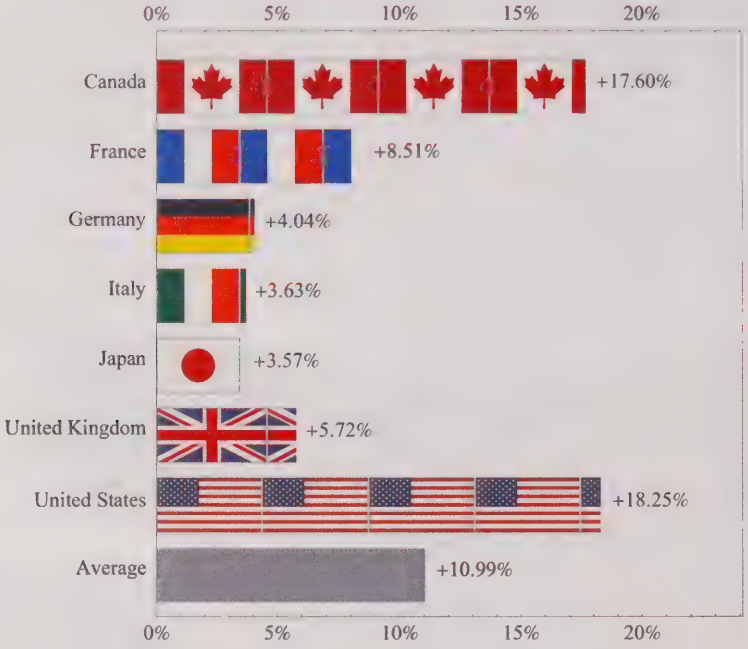


Figure 2.10: Population growth in the G7 1990-2006

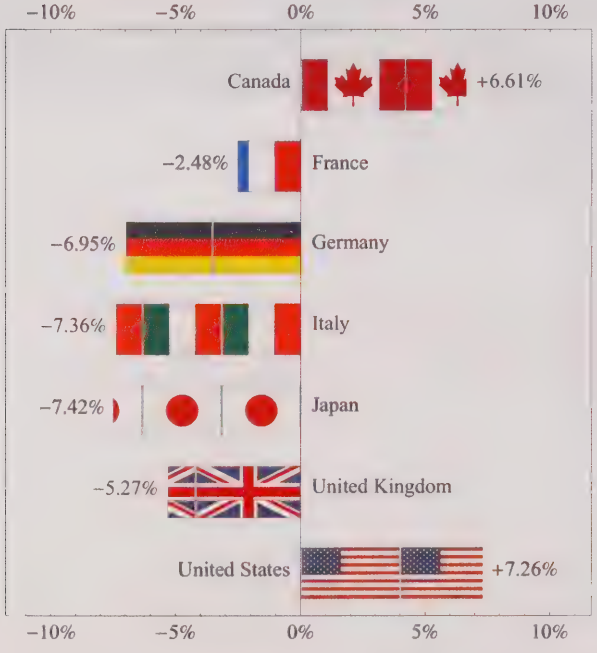


Figure 2.11: Comparison of the G7 vs. an average growth rate weighted by population (1990-2006)

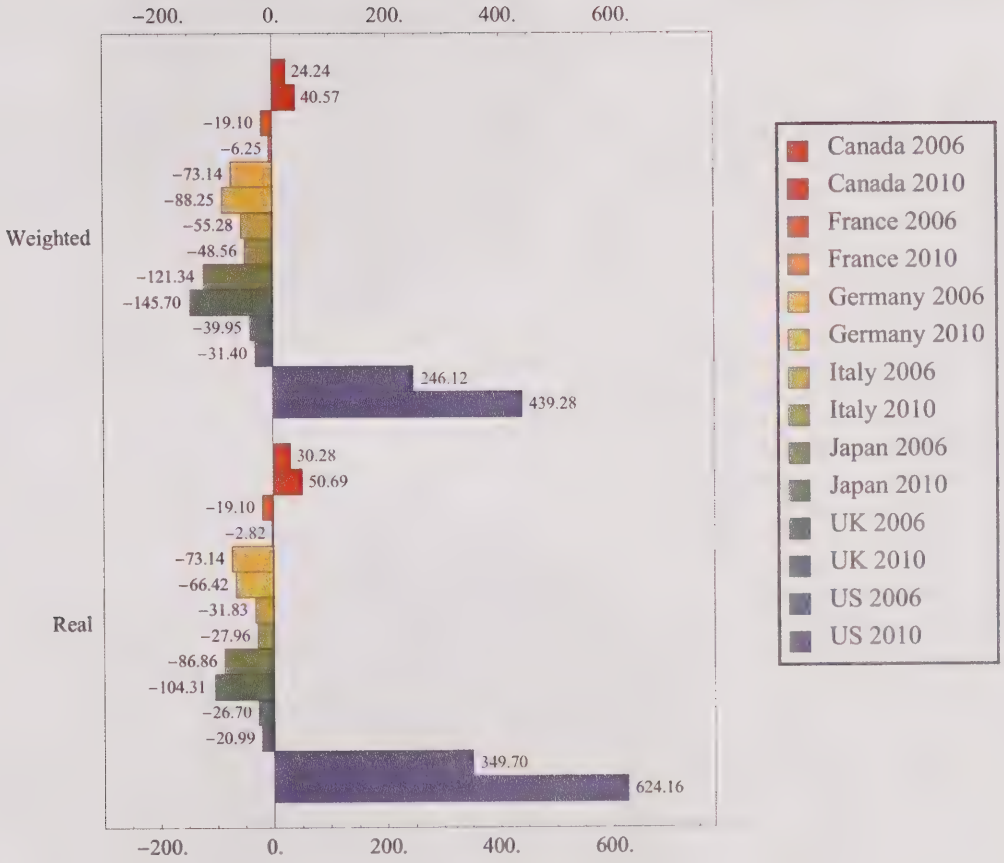


Figure 2.12: Change in $CO_2$ emissions (Mt) from 1990-2006 due to the difference in population growth from the G7 population weighted average

# Chapter 3

# Greenhouse Gas Inventory Information

This chapter summarizes the anthropogenic (human-induced) emissions by sources, and removals by sinks, of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, as submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in April 2009. It also discusses underlying trends in emissions for the period 1990 to 2007 inclusive.

A complete report on the GHG emissions and removals and their associated estimation methodologies for the period 1990 to 2007 can be found in Canada's 2009 submission to the UNFCCC titled National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2007 (Environment Canada, 2009)[1].

The GHGs for which emissions and removals have been estimated in Canada's national inventory are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), sulphur hexafluoride ($SF_6$), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).

The Inventory uses the UNFCCC-agreed upon reporting format that groups GHG estimates into the following six sectors: Energy, Industrial Processes, Solvent and Other Product Use, Agriculture, Waste and Land Use, Land-Use Change and Forestry (LULUCF). Each of these sectors is further subdivided within the inventory and follows, as closely as possible, the UNFCCC categorization of sources and sinks.

## 3.1 Canada's 2007 Greenhouse Gas Inventory

In 2007, Canada emitted about 747 megatonnes (Mt) of $CO_2$ equivalent (Mt $CO_2$ eq) of GHGs to the atmosphere (Table 3.1), excluding LULUCF estimates. Trends in Canada's 2007 GHG emissions and removals estimates are presented in the UNFCCC Common Reporting Format (CRF) in Annex 3.1. Approximately 74% of total GHG emissions in 2007 resulted from the combustion of fossil fuels. Another 9% were from fugitive sources, with the result that 82% of emissions were from the Energy Sector (Figures 3.1 and 3.2).

On an individual GHG basis, $CO_2$ contributed 79% of the total emissions, while $CH_4$ accounted for 13%. $N_2O$ accounted for 6% of the emissions, while PFCs, $SF_6$, and HFCs constituted the remaining 1%.

A significant portion of the emissions from Canada's Energy sector (Table 3.1) is associated with fossil-fuel energy production. A large percentage of those production emissions are related to the export of fossil fuels such as natural gas and crude oil.

Carbon dioxide emissions and removals associated with the Land Use, Land-Use Change and Forestry (LULUCF) sector are not included in the inventory totals. In 2007, total emissions for the LULUCF sector are estimated at about 54 000 kt. Canada contributes about 2% of total global GHG emissions.

## 3.2 Trends in Greenhouse Gas Emissions and Removals 1990 – 2007

In 2007, Canadians contributed about 747 megatonnes of $CO_2$ equivalent (Mt $CO_2$ eq) of GHGs to the atmosphere (Figure 3.3). Since 1990, emissions have increased by about 26%.

Over the same period, however, Canada's economic GHG intensity has decreased by a total of 21% over the period 1990-2007, an average of 1.2% per year. More goods were manufactured, more commercial activity occurred and more travel took place per unit of GHG emissions. These trends are summarized graphically in Figure 3.4. The indexed curves clearly show that GHG emissions per energy used remained static over the period, while economic GHG intensity decreased.

Another trend worth noting is the much larger growth in energy production compared with energy use between 1990 and 2007. The sharp growth in energy exports over the period has had a significant impact on the emission trend. Between 1990 and 2007, oil exports grew by 181% to 4157 petajoules (PJ) (almost three times the rate of growth of oil production), while exports of natural gas increased 173% to 4199 PJ (approximately two and half times the rate of growth of natural gas production). Total of oil and gas energy exports increased by 177% over the same period. Natural

[1] available online http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm

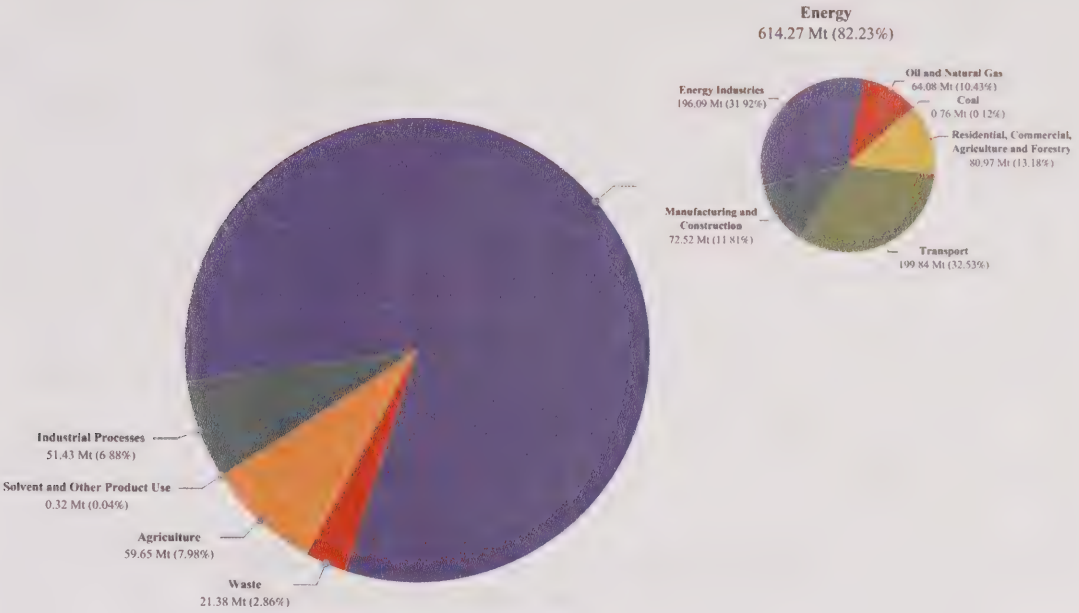


Figure 3.1: Sectoral Breakdown of Canada's GHG Emissions - 2007

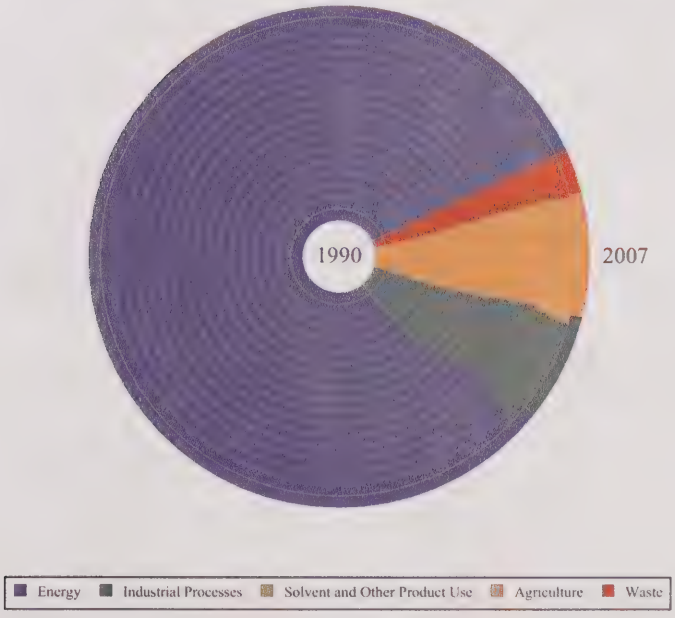


Figure 3.2: Sectoral Breakdown of Canada's GHG Emissions - 1990-2007

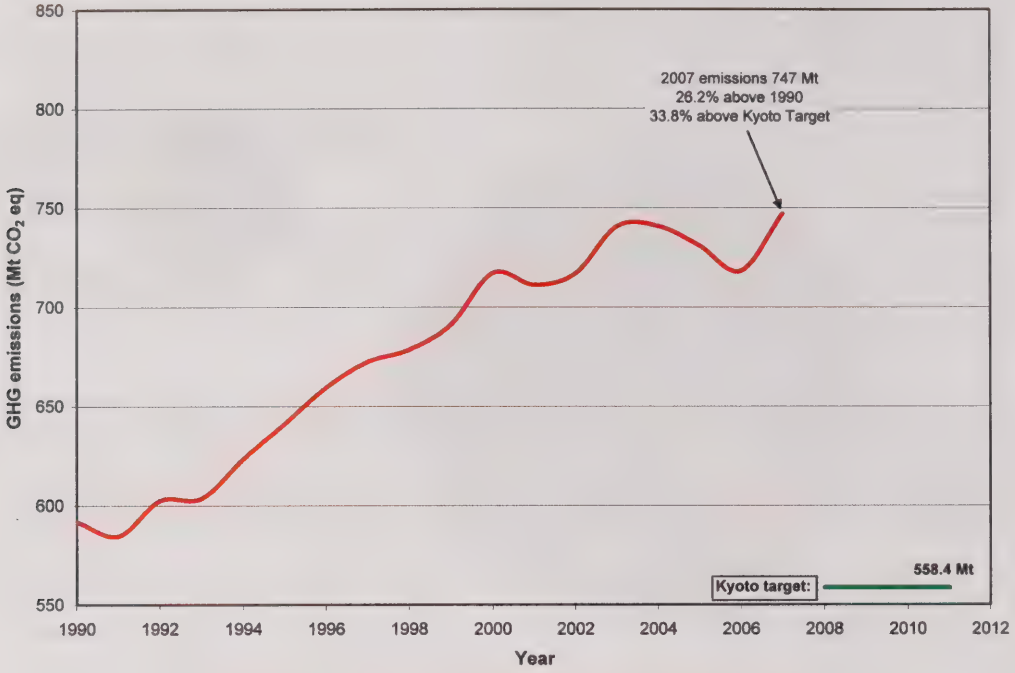


Figure 3.3: Canadian GHG Emission Trend and Kyoto Target

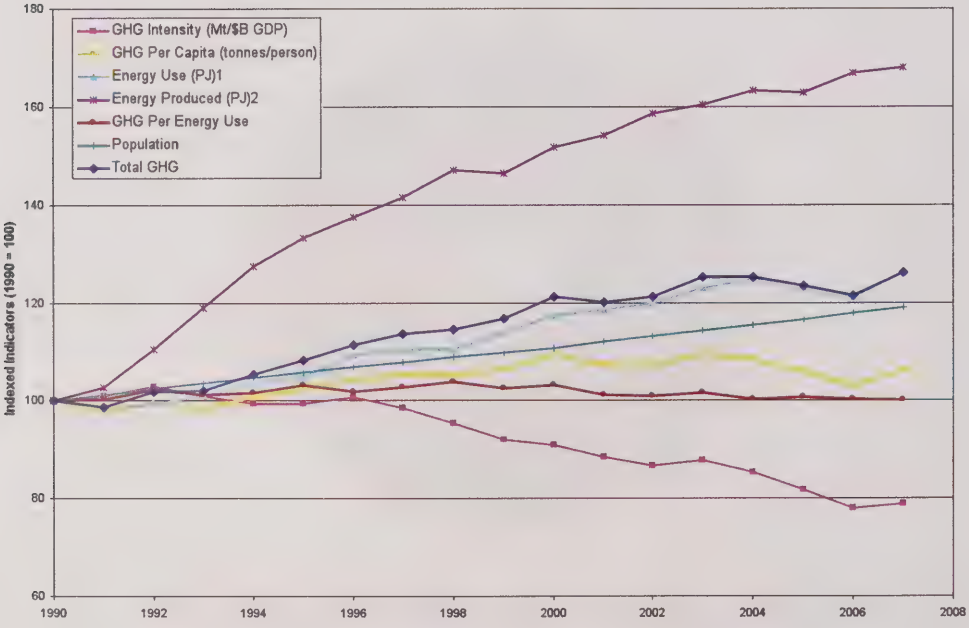


Figure 3.4: Trends in Energy, Population and GHG Emissions Indicators, 1990-2007

| | $CO_2$ eq. | | | $CO_2$ | | | $CH_4$ | | | $N_2O$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2007 | change | 1990 | 2007 | change | 1990 | 2007 | change | 1990 | 2007 | change |
| | Gg | | % | Gg | | % | Gg | | % | Gg | | % |
| **Energy** | **469,000** | **614,000** | **+31** | **424,000** | **550,000** | **+30** | **1,740** | **2,560** | **+47** | **27.3** | **33.2** | **+22** |
| Fuel Combustion Activities | 427,000 | 549,000 | +29 | 414,000 | 534,000 | +29 | 212 | 238 | +12 | 27.2 | 33.1 | +22 |
| Energy Industries | 147,000 | 196,000 | +34 | 144,000 | 193,000 | +33 | 77.5 | 111 | +43 | 2.84 | 3.71 | +31 |
| Manufacturing and Construction | 63,100 | 72,500 | +15 | 62,500 | 71,800 | +15 | 2.78 | 3.35 | +20 | 1.72 | 2.15 | +25 |
| Transport | 145,000 | 200,000 | +37 | 138,000 | 192,000 | +38 | 31 | 30.1 | -3 | 20.4 | 24.7 | +21 |
| Other Sectors | 71,600 | 81,000 | +13 | 68,800 | 78,200 | +14 | 101 | 93.8 | -7 | 2.26 | 2.52 | +11 |
| Fugitive Emissions from Fuels | 42,700 | 64,800 | +52 | 10,600 | 15,900 | +51 | 1,530 | 2,330 | +52 | 0.101 | 0.122 | +21 |
| Solid Fuels | 1,910 | 764 | -60 | - | - | - | 91.2 | 36.4 | -60 | | | |
| Oil and Natural Gas | 40,700 | 64,100 | +57 | 10,600 | 15,900 | +51 | 1,440 | 2,290 | +60 | 0.101 | 0.122 | +21 |
| **Industrial Processes** | **54,800** | **51,400** | **-6** | **31,100** | **39,900** | **+28** | - | - | - | **37.8** | **8.47** | **-78** |
| Mineral Products | 8,290 | 9,430 | +14 | 8,290 | 9,430 | +14 | | | | | | |
| Chemical Industry | 16,700 | 8,860 | -47 | 4,990 | 6,240 | +25 | - | - | - | 37.8 | 8.47 | -78 |
| Metal Production | 19,500 | 13,800 | -29 | 9,770 | 11,100 | +14 | | | | | | |
| Production of HFCs and $SF_6$ | 767 | - | -100 | - | | | | | | | | |
| Consumption of HFCs and $SF_6$ | 1,540 | 6,190 | +302 | - | - | | | | | | | |
| Other (please specify) | 8,030 | 13,100 | +63 | 8,030 | 13,100 | +63 | | | | | | |
| **Solvent and Other Product Use** | **175** | **319** | **+83** | - | - | - | - | - | - | **0.564** | **1.03** | **+83** |
| **Agriculture** | **48,500** | **59,700** | **+23** | - | - | - | **923** | **1,220** | **+32** | **93.8** | **110** | **+17** |
| Enteric Fermentation | 16,900 | 22,600 | +34 | - | - | - | 806 | 1,080 | +34 | | | |
| Manure Management | 5,990 | 7,800 | +30 | - | - | - | 116 | 143 | +23 | 11.4 | 15.5 | +35 |
| Agricultural Soils | 25,500 | 29,200 | +14 | - | - | - | - | - | - | 82.4 | 94.2 | +14 |
| **Waste** | **18,900** | **21,400** | **+13** | **267** | **193** | **-28** | **855** | **974** | **+14** | **2.06** | **2.34** | **+13** |
| Solid Waste Disposal on Land | 17,700 | 20,200 | +14 | - | - | - | 844 | 962 | +14 | | | |
| Wastewater Handling | 738 | 930 | +26 | - | - | - | 10.7 | 12.4 | +16 | 1.66 | 2.16 | +30 |
| Waste Incineration | 401 | 249 | -38 | 267 | 193 | -28 | 0.438 | 0.089 9 | -79 | 0.401 | 0.175 | -56 |
| Total, excluding LULUCF | 592,000 | 747,000 | +26 | 456,000 | 590,000 | +29 | 3,520 | 4,760 | +35 | 162 | 155 | -4 |
| **Land Use Change & Forestry** | **-51,600** | **45,500** | **+188** | **-57,600** | **35,400** | **+161** | **178** | **295** | **+65** | **7.48** | **12.4** | **+66** |
| Forest Land | -78,700 | 38,300 | +149 | -84,100 | 28,700 | +134 | 160 | 283 | +77 | 6.69 | 11.9 | +78 |
| Cropland | 12,700 | -3,390 | -127 | 12,200 | -3,640 | -130 | 13.5 | 7.17 | -47 | 0.608 | 0.334 | -45 |
| Wetlands | 4,960 | 2,650 | -46 | 4,950 | 2,650 | -46 | 0.303 | - | -100 | 0.013 | - | -100 |
| Settlements | 9,510 | 7,840 | -18 | 9,360 | 7,690 | -18 | 4.91 | 4.88 | -1 | 0.168 | 0.163 | -3 |
| Total, including LULUCF | 540,000 | 792,000 | +47 | 398,000 | 626,000 | +57 | 3,690 | 5,060 | +37 | 169 | 167 | -1 |

Table 3.1: Canada's GHG Emissions by Gas and Sector - 2007

gas exports have not experienced substantial changes since 2000.

Beginning in 1997, there was a decoupling of GDP and emissions, with the emission intensity of the Canadian economy decreasing on average by 2.2% per year. This decrease can be explained by structural changes in the composition of the economy, as well as by increases in efficiency, fuel mix changes and changing industrial processes.

Since 2003, fossil fuel generation has varied with the availability of electricity from hydro, nuclear and, to some extent, wind power sources. Hydroelectric power generation increased throughout Canada as a result of higher water levels (precipitation in each of 2004, 2005 and 2006 was greater than the 30-year average) and increased hydro-generating capacity. At the same time, efforts have been made in Ontario to decrease coal generation and bring more nuclear plants back on line. These efforts were more successful in 2006 than 2007, when some nuclear outages necessitated increased coal generation.

## 3.3 Greenhouse Gas Trends by UNFCCC Sector 1990-2007

In Canada, between 1990 and 2007, emissions in all but one of the UNFCCC sectors increased (Table 3.1). Since 1990, growth in emissions has resulted primarily from Electricity and Heat Generation and areas such as Fossil Fuel Industries, Mining, and Transportation.

### 3.3.1 Energy - 2007 GHG Emissions, 614 Mt

The largest portion of the growth in GHG emissions/removals from 1990 to 2007 inclusive is observed in the Energy sector. In terms of relative growth, fugitive emissions from Oil and Natural Gas have increased faster than any other category in the Energy Sector, rising by 57% between 1990 and 2007.

### 3.3.1.1 Fuel Combustion Activities

#### 3.3.1.1.1 Energy Industries - 2007 GHG Emissions, 196 Mt

The Energy Industries subsector accounts for the largest portion of Canada's fuel combustion emissions (26% of Canada's total). In 2007, combustion emissions from the Energy Industries category totalled 196 Mt, an increase of 34% from the 1990 level of 147 Mt.

##### Public Electricity and Heat Production - 2007 GHG Emissions, 126 Mt

Public Electricity and Heat Production, a constituent of the Energy Industries subsector, accounted for 17% (126 Mt) of Canada's 2007 GHG emissions (Table 3.2) and was responsible for 20% of the total emission growth between 1990 and 2007. Overall emissions from this category increased 32% (31 Mt) since 1990.

The GHG emissions associated with coal-fired electricity generation, which had been increasing since the mid-1990s, have fluctuated regularly since peaking in 2001. Several factors have major effects on GHG emissions associated with coal-fired generation, including: fuel costs, economic factors, the regulatory environment, fuel switching, the use of less GHG-intensive coal, increases in renewables, and interprovincial and international trade. The impact of wind power will begin to play a greater role in the coming years as the installed wind capacity in Canada continues to grow at a rapid rate.

##### Petroleum Refining - 2007 Net Emissions, 18 Mt

The Petroleum Refining category mainly includes emissions from the combustion of fossil fuels during the production of refined petroleum products (RPPs). In 2007, GHG emissions from this category totalled approximately 18 Mt.

##### Manufacture of Solid Fuels and Other Energy Industries - 2007 Net Emissions, 52 Mt

The Manufacture of Solid Fuels and Other Energy Industries category encompasses fuel combustion emissions associated with the upstream oil and gas (UOG) industry. In 2007, GHG emissions totalled about 52 Mt from this subsector. As shown in Table 3.2, between 1990 and 2007, emissions from these two categories increased by about 18 Mt, or 37%. This growth is due to increases in natural gas and oil production, particularly crude bitumen and heavy crude oil.

#### 3.3.1.1.2 Manufacturing Industries and Construction - 2007 GHG Emissions, 72.5 Mt

Emissions from the Manufacturing Industries and Construction subsector were responsible for 9.7% of Canada's total GHG emissions in 2007, up 9.4 Mt from 1990. The majority of the overall increase can be attributed to the Mining category, which has seen a 276% growth since 1990. The largest decrease was -57% in the Pulp, Paper and Print category, which can be attributed to decreased demand, fuel switching, and changes in manufacturing operations.

#### 3.3.1.1.3 Transport - 2007 GHG Emissions, 200 Mt

Transport is a large and diverse subsector, accounting for almost 27% of Canada's GHG emissions in 2007. This subsector includes emissions from fuel combustion for the transport of passengers and freight in five distinct subcategories: Road Transportation, Civil Aviation (Domestic Aviation), Navigation (Domestic Marine), Railways, and Other Transportation (Off-Road and Pipelines).

From 1990 to 2007, GHG emissions from transport rose 37.5%, or 55 Mt. Overall, transport was the second largest emission-producing category in 2007, contributing 200 Mt and accounting for 35% of Canada's emission growth from 1990 to 2007.

As shown in Table 3.3, the growth in road transport emissions is due not only to the 39% increase in the total vehicle fleet, but also to a shift in light-duty vehicle purchases from cars (light-duty gasoline vehicles (LDGVs)) to trucks (light-duty gasoline trucks (LDGTs)), which, on average, emit 40% more GHGs per kilometre. Over the 1990-2007 period, the increase of 24 Mt and 19 Mt for LDGTs and heavy-duty diesel vehicles (HDDVs), respectively, reflects the trend towards the increasing use of SUVs, minivans and pick-ups for personal transportation and heavy-duty trucks for freight transport.

#### 3.3.1.1.4 Other Energy Sectors - 2007 GHG Emissions, 81 Mt

The Other Sectors subsector comprises fuel combustion emissions from the Residential and Commercial categories, as well as stationary fuel combustion emissions from the Agriculture and Forestry category. Overall, this subsector exhibited increases in GHG emissions of 13% from 1990 to 2007, while individual subcategories within it demonstrated a variety of changes.

#### 3.3.1.1.5 Residential and Commercial

Emissions in these categories arise primarily from the combustion of fuel to heat in residential and commercial buildings. Fuel combustion in the Residential and Commercial and Institutional categories accounted

| | 1990 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| | Mt $CO_2$ eq | | | | |
| Public Electricity and Heat Production | 95.5 | 126.8 | 124.7 | 117 | 126 |
| Electricity Generation | 95 | 125 | 123 | 116 | 125 |
| Heat Generation | 0.7 | 2.03 | 1.4 | 1.37 | 1.4 |
| Petroleum Refining | 16 | 18 | 17 | 16 | 18 |
| Manufacture of Solid Fuels and Other Energy Industries | 36 | 53 | 49 | 50 | 52 |
| Energy Industries Total | 147.5 | 197.8 | 190.7 | 183 | 196 |

Table 3.2: Energy Industries GHG Contribution

| | 1990 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| | Mt $CO_2$ eq | | | | |
| **Transport** | **145** | **188** | **192** | **191** | **200** |
| Civil Aviation (Domestic Aviation) | 6.4 | 7.8 | 7.9 | 7.7 | 7.8 |
| Light-duty Gasoline Vehicles | 45.8 | 41.1 | 39.9 | 39.9 | 41.1 |
| Light-duty Gasoline Trucks | 20.7 | 42.0 | 43.1 | 43.6 | 45.0 |
| Heavy-duty Gasoline Vehicles | 7.81 | 6.40 | 6.30 | 6.43 | 6.64 |
| Motorcycles | 0.146 | 0.245 | 0.252 | 0.256 | 0.265 |
| Light-duty Diesel Vehicles | 0.355 | 0.431 | 0.432 | 0.435 | 0.450 |
| Light-duty Diesel Trucks | 0.707 | 1.99 | 2.13 | 2.23 | 2.33 |
| Heavy-duty Diesel Vehicles | 20.7 | 36.5 | 38.1 | 38.9 | 40.1 |
| Propane & Natural Gas Vehicles | 2.2 | 0.86 | 0.72 | 0.79 | 0.83 |
| Railways | 7 | 6 | 6 | 6 | 7 |
| Navigation (Domestic Marine) | 5.0 | 6.6 | 6.4 | 5.8 | 6.1 |
| Off-road Gasoline | 6.7 | 7.7 | 7.3 | 6.7 | 7.4 |
| Off-road Diesel | 15 | 22 | 23 | 23 | 25 |
| Pipelines | 6.85 | 8.47 | 10.1 | 9.61 | 9.80 |

Table 3.3: GHG Emissions from Transport, Selected Years

for 5.8% (44 Mt) and 4.7% (35 Mt), respectively, of all GHG emissions in 2007.

As shown in Figure 3.5, residential emissions fluctuate on an annual basis and, overall, have remained unchanged between 1990 and 2007. Over the short term, emissions increased by 3.8 Mt from 2006, 1.8 Mt from 2005 and 0.7 Mt from 2004. Commercial and Institutional emissions, however, increased 9.5 Mt or 37% between 1990 and 2007 and show a trend similar to that illustrated by the Residential sector. Combined, the two categories exhibited an overall increase of 9.5 Mt or 14% between 1990 and 2007.

GHG emissions, particularly in the Residential sector, track heating degree-days (HDDs) closely (as shown in Figure 3.5). This indicates the important influence weather can have on space heating requirements and, therefore, on the demand for natural gas, home heating oil and biomass fuels.

Stationary fuel combustion related emissions from the Agriculture and Forestry categories amounted to 2.2 Mt in 2007, a decrease of 6% from 1990. Emissions from these categories contributed less than 0.3% of the total for 2007.

#### 3.3.1.2 Fugitive Emissions from Fuels - 2007 GHG Emissions, 64.8 Mt

Fugitive emissions from fossil fuels are the intentional or unintentional releases of GHGs from the production, processing, transmission, storage, and delivery of fossil fuels. Released gases that are combusted before disposal (e.g., flaring of natural gases at oil and gas production and processing facilities) are also considered fugitive emissions. They constituted 8.7% of Canada's total GHG emissions for 2007 and contributed 14% to the growth in emissions between 1990 and 2007.

In total, fugitive emissions grew by about 52% between 1990 and 2007, from 42.7 to 64.8 Mt, with emissions from the Oil and Natural Gas category contributing 99% of the total fugitive emissions in 2007, far

overshadowing the 1% contribution from Coal Mining. Although fugitive releases from the Solid Fuels category (i.e. coal mining) decreased by 1.2 Mt (60%) between 1990 and 2007 as a result of the closing of many mines in eastern Canada, emissions from oil and natural gas increased 57% during the same period.

### 3.3.2 Industrial Processes - 2007 GHG Emissions, 51.4 Mt

The Industrial Processes Sector includes GHG emissions that are direct by-products of processes, including Mineral Products, Chemical Industry, Metal Production, Production and Consumption of Halocarbons and $SF_6$, and Other and Undifferentiated Production (Table 3.4). GHG emissions from the Industrial Processes sector contributed 51.4 Mt to the 2007 national GHG inventory, compared with 54.8 Mt in 1990.

As shown in Table 3.4, between 1990 and 2007, the overall sector emissions decreased by approximately 3.4 Mt (6.2%). This change could be explained by significant emission reductions in adipic acid production ($N_2O$), aluminium production (PFCs), and magnesium production ($SF_6$), which were offset by growths in emissions from consumption of HFCs, other and undifferentiated production ($CO_2$) , aluminium production ($CO_2$), and cement production ($CO_2$). The chemical and metal industries have made progress in controlling emissions over the years. For instance, Canada's only adipic acid production plant installed an emission abatement system in 1997, which cut its $N_2O$ emissions down by 86% (9.2 Mt $CO_2$ eq) between 1990 and 2007. While increasing its production by 97% (1.5 Mt) between 1990 and 2007, the aluminium industry has succeeded in reducing the occurrence of anode effects (hence the PFC emissions, by 67% or 4.4 Mt $CO_2$ eq) by incorporating computerized sensors and automated alumina feeders. The magnesium production industry also showed a decrease in emissions because of replacement of $SF_6$ with alternatives, used as cover gas, and the closure of plants over the years.

There has been an emission growth of 875% (4.4 Mt $CO_2$ eq) for consumption of halocarbons since 1995. This could be explained by the fact that more ozone-depleting substances (ODSs) have been replaced by the hydrofluorocarbons (HFCs) within the refrigeration and air conditioning (AC) markets since the Montreal Protocol came into effect in 1996. The non-energy (feedstock) use of fuels in the petrochemical industry has considerably increased over the years, justifying by and large the emission growth of 63% (5.1 Mt $CO_2$ eq) seen in the category of Other and Undifferentiated Production. Increasing production caused the growth in $CO_2$ emissions of 88% (2.4 Mt $CO_2$ eq) from the aluminium industry, since $CO_2$ comes from the reduction of alumina with carbon anodes (an essential reaction in the production process) from which emissions cannot be easily controlled. For Cement Production, the emission increase of 33% (1.8 Mt $CO_2$ eq) resulted from growth in clinker production, which in turn was driven by the increases in the domestic and international (mainly U.S.) construction activities.

### 3.3.3 Solvent and Other Product Use

#### 2007 GHG Emissions, 0.32 Mt

The Solvent and Other Product Use Sector accounts for emissions related to the use of $N_2O$ as an anaesthetic in medical applications and as a propellant in aerosol products. The emission trends were primarily driven by the domestic demand for $N_2O$ for anaesthetic or propellant purposes.

### 3.3.4 Agriculture

#### 2007 GHG Emissions, 60 Mt

Agricultural emissions accounted for 60 Mt or 8% of total 2007 GHG emissions for Canada, an increase of 11 Mt since 1990. All these emissions are from non-energy sources; $N_2O$ accounts for about 57% of sectoral 2007 emissions and $CH_4$ for about 43% in 2007. This information is summarized in Figure 3.6.

Livestock emissions consist of enteric fermentation from domestic animals (i.e. dairy and beef cattle, swine, sheep, goats and horses) and manure management. These emissions accounted for 51% of the Agriculture Sector's total GHG emissions in 2007.

Agricultural soil emissions consist of direct $N_2O$ emissions from synthetic nitrogen fertilizers, animal manure applied to cropland, crop residue decomposition, summer fallow, tillage practices, irrigation and cultivation of organic soils; indirect $N_2O$ emissions from volatilization and leaching of fertilizer, manure and crop residue nitrogen; and $N_2O$ emissions from manure on pasture, range and paddock. These sources accounted for about 49% of the Agriculture Sector's total GHG emissions in 2007.

In the period from 1990 to 2007, $CH_4$ emissions from enteric fermentation increased by approximately 34%, emissions from manure management systems 32% and soil $N_2O$ emissions by approximately 14%. These increases result mainly from the expansion of the beef cattle and swine populations, combined with an increase in the consumption of synthetic nitrogen fertilizer.

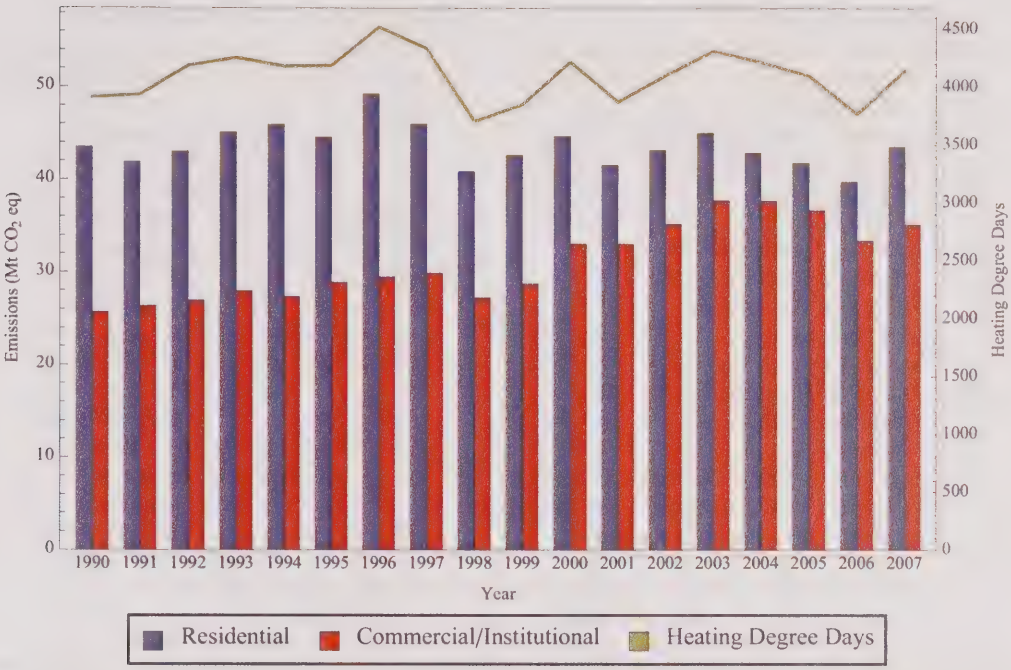


Figure 3.5: GHG Emissions and HDDs from Residential and Commercial Sectors, 1990-2007

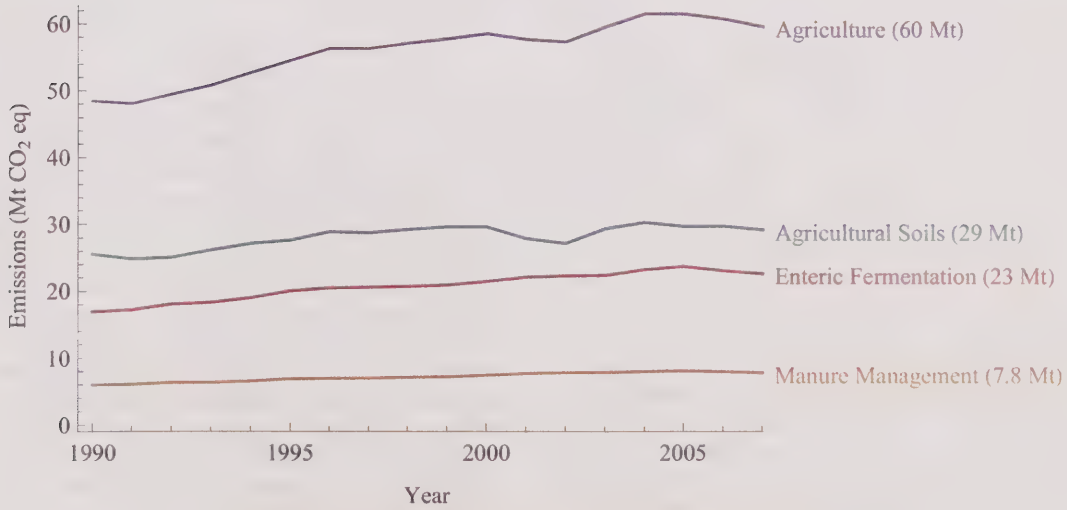


Figure 3.6: GHG Emissions from Agriculture, 1990 to 2007

| | 1990 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| | Mt $CO_2$ eq | | | | |
| **Industrial Processes** | **54.8** | **55.4** | **55.1** | **54.6** | **51.4** |
| Mineral Products | 8.3 | 9.5 | 9.5 | 9.6 | 9.4 |
| Cement Production | 5.4 | 7.1 | 7.2 | 7.3 | 7.3 |
| Lime Production | 1.8 | 1.8 | 1.7 | 1.6 | 1.6 |
| Limestone and Dolomite Use | 0.7 | 0.2 | 0.3 | 0.3 | 0.3 |
| Soda Ash Use | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 |
| Magnesite Use | 0.1 | 0.2 | 0.2 | 0.2 | 0.1 |
| Chemical Industry | 17.0 | 11.0 | 10.0 | 9.0 | 8.9 |
| Ammonia Production | 5.0 | 6.8 | 6.3 | 6.6 | 6.2 |
| Nitric Acid Production | 1.0 | 1.2 | 1.3 | 1.2 | 1.1 |
| Adipic Acid Production | 10.7 | 3.1 | 2.6 | 1.2 | 1.5 |
| Metal Production | 19.5 | 16.7 | 16.5 | 16.8 | 13.8 |
| Iron and Steel Production | 7.1 | 7.2 | 7.0 | 7.8 | 6.0 |
| Aluminium Production | 9.3 | 7.3 | 8.2 | 7.7 | 7.3 |
| Magnesium Production | 2.9 | 2.0 | 1.1 | 1.2 | 0.3 |
| Magnesium Casting | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Production and Consumption of Halocarbons | 0.7 | 4.7 | 5.2 | 5.0 | 4.9 |
| $SF_6$ Use in Electric Utilities and Semiconductors | 1.5 | 0.8 | 1.2 | 1.5 | 1.2 |
| Other and Undifferentiated Production | 8.0 | 12.5 | 12.4 | 12.6 | 13.1 |

Table 3.4: GHG Emissions from Industrial Processes by Category, Selected Years

Between 2004 and 2007, there was a decrease of 2 Mt $CO_2$ eq in agricultural emissions, attributed to the decline of beef cattle populations and thus of emissions from manure management and enteric fermentation.

| | 1990 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| | kt $CO_2$ eq | | | | |
| **Agriculture** | **48,000** | **62,000** | **62,000** | **61,000** | **60,000** |
| Enteric Fermentation –$CH_4$ | 17,000 | 23,000 | 24,000 | 23,000 | 23,000 |
| Dairy Cattle | 2,700 | 2,500 | 2,500 | 2,500 | 2,400 |
| Beef Cattle | 14,000 | 20,000 | 20,000 | 20,000 | 19,000 |
| Others | 610 | 1,100 | 1,100 | 1,100 | 1,000 |
| Manure Management –$CH_4$ | 6,000 | 8,000 | 8,100 | 8,000 | 7,800 |
| Dairy Cattle | 570 | 530 | 530 | 520 | 510 |
| Beef Cattle | 700 | 880 | 890 | 860 | 840 |
| Swine | 1,100 | 1,600 | 1,600 | 1,600 | 1,500 |
| Poultry | 70 | 90 | 90 | 90 | 90 |
| Others | 20 | 40 | 40 | 40 | 40 |
| Manure Management –$N_2O$ All Animal Types | 3,500 | 4,900 | 5,000 | 4,900 | 4,800 |
| Agricultural Soils ($N_2O$) | 26,000 | 30,000 | 30,000 | 30,000 | 29,000 |
| Direct Sources | 14,000 | 15,000 | 15,000 | 15,000 | 15,000 |
| Synthetic Nitrogen Fertilizers | 5,900 | 7,600 | 7,000 | 7,100 | 7,100 |
| Manure Applied as Fertilizers | 1,900 | 2,300 | 2,300 | 2,300 | 2,200 |
| Crop Residue Decomposition | 4,800 | 5,000 | 5,200 | 5,400 | 5,200 |
| Cultivation of Organic Soils | 60 | 60 | 60 | 60 | 60 |
| Conservation Tillage | -300 | -860 | -900 | -860 | -890 |
| Summerfallow | 1,300 | 830 | 800 | 700 | 640 |
| Irrigation | 280 | 350 | 350 | 340 | 330 |
| Pasture, Range, and Paddock Manure | 2,600 | 4,000 | 4,100 | 4,000 | 3,900 |
| Indirect Sources | 9,100 | 11,000 | 11,000 | 11,000 | 11,000 |

[a] The negative values reflect a reduced $N_2O$ emission due to the adoption of conservation tillage. Totals may not add up due to rounding.

Table 3.5: Short-Term and Long-Term Changes in GHG Emissions from the Agriculture Sector

## 3.3.5 Waste

### 2007 GHG Emissions, 21 Mt

From 1990 to 2007, GHG emissions from the Waste Sector increased 13%, while over the same period, total national GHG emissions grew by 26% (Figure 3.7). In 2007, these emissions represented 2.9% of the total national GHG emissions, compared with a 3.2% contribution in 1990. Of the 21 Mt total emissions from this sector in 2007, solid waste disposal on land, which includes municipal solid waste (MSW) landfills and wood waste landfills, accounted for 20 Mt. $CH_4$ emissions produced by the decomposition of biomass in MSW landfills were responsible for 82% of the emissions from this sector. Emissions from municipal wastewater treatment and incineration of waste (excluding emissions from incineration of biomass material) contributed 0.93 Mt and 0.25 Mt, respectively, to the total from the Waste Sector. Figure 3.7 presents the emission trends for each of the three subsectors compared with the total emissions for the Waste Sector between 1990 and 2007.

Methane emissions from MSW landfills increased by 16% between 1990 and 2007, despite an increase in landfill gas capture and combustion of 71% over the same period. Approximately 330 kt of $CH_4$ (or 6 930 kt $CO_2$ eq) were captured by the 65 landfill gas collection systems operating in Canada (Environment Canada 2009). Of the total amount of $CH_4$ collected in 2007, 50% (165 kt) was utilized for various energy purposes and the remainder was flared.

From 1990 to 2007, the population growth trend (19%) exceeded that of the sector emissions (13%). The decline in the growth of emissions per capita from waste observed in the mid-1990s, shown in Figure 3.8, is directly attributable to $CH_4$ capture at landfills and waste diversion programs. However, from 1997 to 1999, there was a reduction followed by an increase in the quantities of landfill gas captured. These changes have an inversely proportional influence on the emissions per capita, which is apparent in Figure 3.8.

### 3.3.6 Land Use, Land-Use Change and Forestry

**2007 Net GHG Emissions, 45 Mt, not included in national totals**

The LULUCF Sector reports GHG fluxes between the atmosphere and Canada's managed lands, as well as those associated with land-use changes. The LULUCF UNFCCC categories include the Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land, and Other subsectors The net LULUCF flux, calculated as the sum of $CO_2$ emissions and removals and non-$CO_2$ emissions, displays high interannual variability over the reporting period. In 2007, this net flux amounted to emissions of 45 Mt (Figure 3.9)

In accordance with UNFCCC accounting rules, all emissions and removals in the LULUCF Sector are excluded from the national totals.

GHG emissions from sources and removals by sinks are estimated and reported for four categories of managed lands: Forest Land, Cropland, Wetlands and Settlements.

The Forest Land category includes GHG emissions from and removals by Canada's managed forests. Managed forests display the highest interannual variability of all categories and exert an overriding influence on the net sectoral GHG balance and trend. The net GHG flux reflects the difference between carbon uptake by tree growth and emissions due to anthropogenic and natural disturbances, specifically forest management activities, wildfires and insect infestations. The high variability in the net flux from managed forests is associated with the immediate impact of wildfires, which alone accounted for annual emissions of between 11 and 291 Mt over the period from 1990 to 2007 (Table 3.6) Over the last 10 years, forest management activities, namely harvesting, account for annual average emissions of 184 Mt, a 21% increase since 1990 levels; note that the current default approach ignores long-term carbon storage in wood products.

Both short-term and long-term trends should therefore be interpreted with caution, given that the sector as a whole has significant interannual variability resulting from large fluctuations in the severity of the fire season, with an additional random effect due to the location of fires with respect to managed forests (as opposed to non-managed).

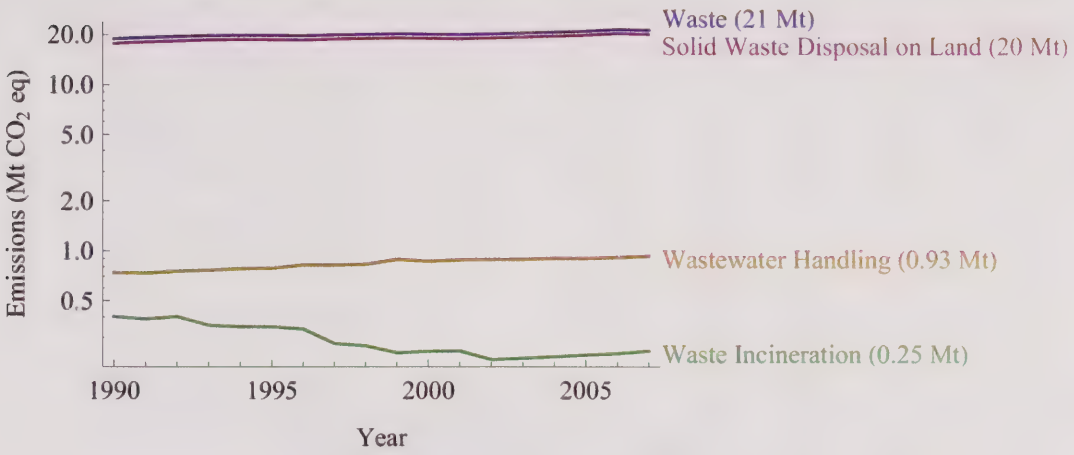


Figure 3.7: GHG Emissions from Waste, 1990-2007

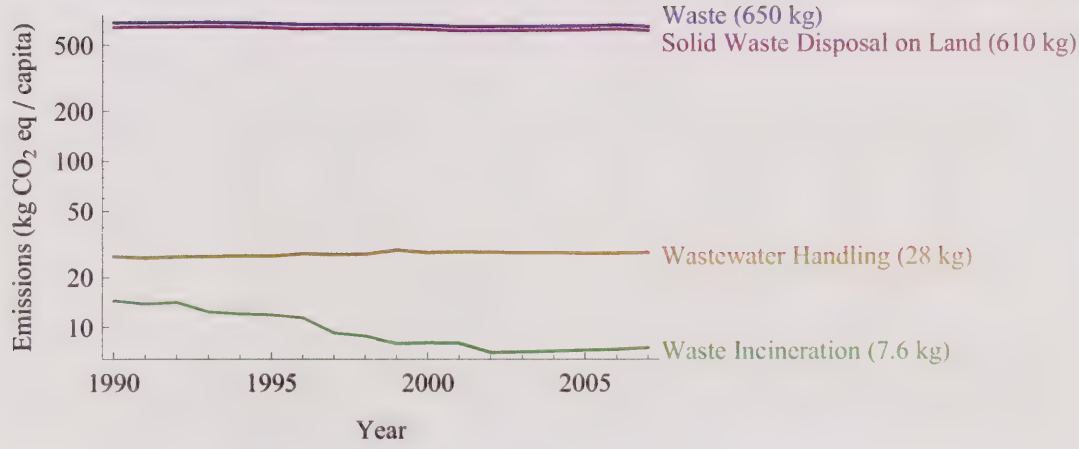


Figure 3.8: Per Capita GHG Emission Trend - Waste, 1990 to 2007

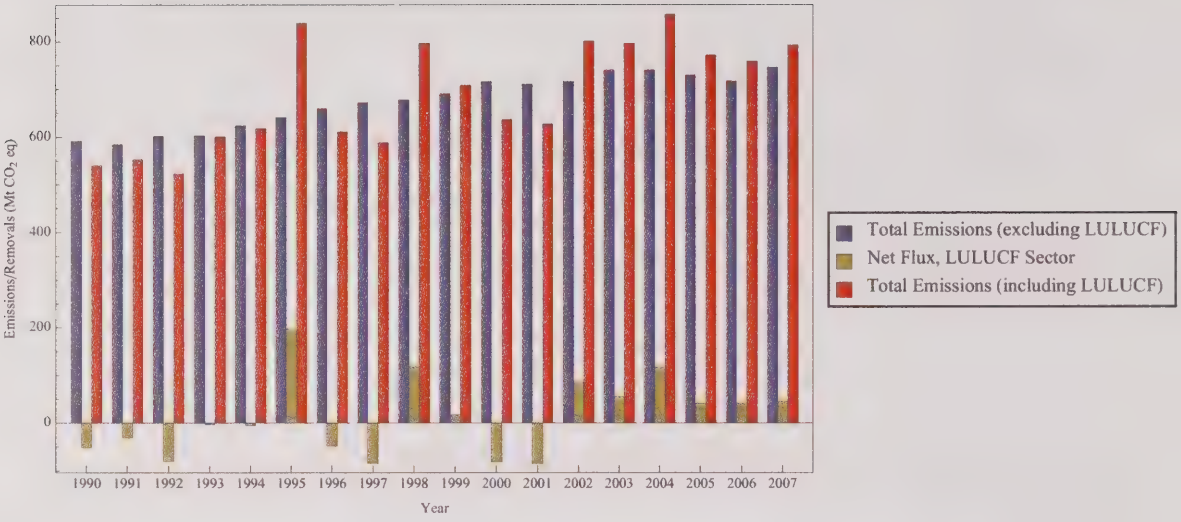


Figure 3.9: GHG Emissions from LULUCF Relative to Total Canadian Emissions, 1990-2007

| | 1990 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| | kt $CO_2$ eq | | | | |
| **Land Use, Land-Use Change and Forestry**[a] | **-52,000** | **120,000** | **41,000** | **41,000** | **45,000** |
| **Forest Land** | -79,000 | 110,000 | 32,000 | 33,000 | 38,000 |
| Forest Land Remaining Forest Land | -78,000 | 110,000 | 33,000 | 34,000 | 39,000 |
| Land Converted to Forest Land | -1,000 | -1,000 | -1,000 | -1,000 | -1,000 |
| **Cropland** | 13,000 | -960 | -2,100 | -2,300 | -3,400 |
| Cropland Remaining Cropland | -1,400 | -9,100 | -9,700 | -10,000 | -11,000 |
| Land Converted to Cropland | 14,000 | 8,200 | 7,700 | 8,000 | 7,500 |
| **Grassland** | NE | NE | NE | NE | NE |
| Grassland Remaining Grassland | NE | NE | NE | NE | NE |
| Land Converted to Grassland | NE | NE | NE | NE | NE |
| **Wetlands** | 5,000 | 3,000 | 3,000 | 3,000 | 3,000 |
| Wetlands Remaining Wetlands | 1,000 | 2,000 | 2,000 | 2,000 | 1,900 |
| Land Converted to Wetlands | 4,000 | 1,000 | 1,000 | 900 | 800 |
| **Settlements** | 10,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Settlements Remaining Settlements | -100 | -200 | -200 | -200 | -200 |
| Land Converted to Settlements | 10,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Forest conversion (memo item)[b] | 27,000 | 21,000 | 21,000 | 20,000 | 20,000 |
| Grassland conversion (memo item)[b,c] | 300 | 200 | 200 | 200 | 200 |

[a] Totals may not add up due to rounding.
[b] Already included in land converted to cropland, land converted to wetlands, and land converted to settlements; and in cropland remaining cropland and wetlands remaining wetlands (for residual emissions post-20 years, 10 years for reservoirs).
[c] Includes conversion of agricultural grassland to cropland and of tundra to settlement.

Table 3.6: LULUCF Sector Net GHG Flux Estimates, Selected Years

## 3.4 Uncertainties

While national GHG inventories should be accurate, complete, comparable, transparent and verifiable, estimates will always inherently carry some uncertainty. Uncertainties in the inventory estimates may be caused by systematic model uncertainty or (more likely) due to random uncertainties present within the input parameters. While reducing model uncertainty requires in-depth reviews of the estimation models, random uncertainties may be reduced by improvements to the activity data regimes and evaluation of emission factors and other model parameters. The primary purpose of quantitative uncertainty information is to set priorities to improve the accuracy of future inventories and to guide decisions about which methods to use. Typically, the uncertainties associated with the trends and the national totals are much lower than those associated with individual gases and sectors.

The overall level uncertainty of Canada's national inventory (without LULUCF), as at 2001 (2003 NIR submission; see Environment Canada 2003), falls within a range of -3% to +6% for all GHGs combined. $N_2O$ exhibits the highest uncertainty range in the national inventory, with a range of -8% to +80%, followed by HFCs, with a range of -22% to +58%. The largest contributor to the inventory, $CO_2$, exhibits an uncertainty of -4% to 0% (ICF Consulting 2005). Canada's inventory uncertainty estimate falls within the range of uncertainty reported by other Annex I countries. Although the study of uncertainty was performed on the 2003 NIR data, the level uncertainties assessed are assumed to be representative of the current inventory.

## 3.5 National Systems

The contact information for the national entity and its designated representative with overall responsibility for the national inventory is:
Director, Greenhouse Gas Division
Science and Risk Assessment Directorate
Environment Canada
819-994-3098
200 Sacré-Coeur Blvd.
Gatineau, Quebec
K1A 0H3

### 3.5.1 Institutional, Legal, and Procedural Arrangements in Inventory Preparation

The Canadian Environmental Protection Act, 1999 (CEPA 1999) is the legislative authority for Environment Canada to establish the national system and to designate Environment Canada's Greenhouse Gas Division as the single national entity with responsibility for the preparation and submission of the national inventory to the UNFCCC (Government of Canada 1999). Recognizing the need to draw on the best available technical and scientific expertise and information in accordance with good practice and international quality standards, the Greenhouse Gas Division has defined roles and responsibilities for the preparation of the inventory, both internally and externally. Figure 3.10 identifies the different partners of the inventory agency and their contribution.

Inventory experts in the Greenhouse Gas Division develop, analyse and verify activity data, methods, emission factors and the emission and removal estimates. The Division develops, reports, and publishes the NIR and the Common Reporting Format (CRF) tables. The Greenhouse Gas Division also manages the quality and the archiving systems, performs trend analysis, publishes fact sheets and acts as a clearinghouse for GHG information and technical guidance on GHG quantification. Moreover, the Greenhouse Gas Division manages the Greenhouse Gas Emissions Reporting Program which requires annual reporting from facilities whose emissions exceed the reporting threshold of 50 kt $CO_2$ eq. The facility data collected under this program, although not directly used in the development of the NIR, serve as an important component of the overall inventory development process in comparing and verifying the inventory estimates. Groups at Environment Canada other than the Greenhouse Gas Division also contribute data on waste and waste management, residential fuel use of biomass and emissions of $SF_6$, ozone and aerosol precursors.

Because sources and sinks of GHGs originate from a tremendous range of economic sectors and activities, the Greenhouse Gas Division is involved in many partnerships with data providers and expert contributors in a variety of ways, ranging from informal to formal arrangements.

### 3.5.2 Process for Inventory Preparation

Continuous data collection and improvements are integral parts of the national inventory planning and quality management cycles. Each year, an evaluation is conducted based on the results of the lessons-learned review of the previous inventory cycle, QA/QC follow-up, the UNFCCC review report, collaboration with provincial and territorial governments and the improvement plan to identify priorities and areas for improvement. Based on these outcomes, methodologies and emission factors are reviewed, developed and/or refined. QA reviews of methodologies and emission factors are undertaken for categories for which a change in methodology or emission factor is proposed and for categories that are scheduled for a QA review of methodology or emission factor. The data used to compile the national inventory are generally from published sources. Data are collected either electronically or manually (hard copies) from the source agencies and are entered into spreadsheet-based emission accounting systems, databases and/or models. Emissions are calculated by designated inventory experts, reviewed internally and then reported according to UNFCCC guidelines in the CRF and the NIR. QC checks and estimates are signed off by sectoral managers before the report and national totals are prepared. The inventory process also involves key category assessment, recalculations, uncertainty work and documentation preparation. Comments from the review are documented and, where appropriate, incorporated in the NIR and CRF, which are normally submitted to the UNFCCC electronically by April 15 of each year. The NIR is then also published on Environment Canada's website pending any final editing and translation.

A key source or sink is a category prioritized because its estimate has a significant influence on a country's inventory in terms of absolute emissions, emissions trend, or both. Key category analysis is required by the UNFCCC Guidelines and IPCC 2006 (Volume 1, Chapter 4) and allows the prioritization of resources and efforts. Key categories are the focus of QA/QC and to the extent possible, country specific methodologies and emission factors (as opposed to default) are used for their estimation. Each year, an Approach 1 assessment of key categories is performed as part of the in-

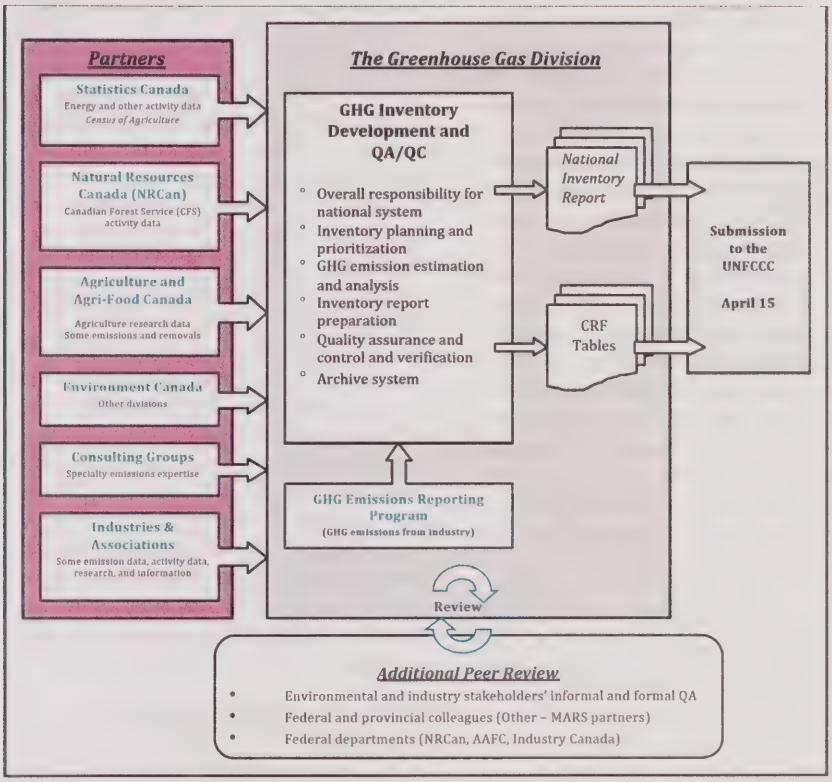


Figure 3.10: Partners of the National System

ventory process. The GHG Division is working towards incorporating an Approach 2 key category assessment; a category's contribution to the overall emission level and trend is weighted by the quantitative uncertainty estimate of each category.

### 3.5.3 Process for Recalculation of Data

As required under the United Nations Framework Convention on Climate Chance (UNFCCC), all Annex 1 Parties are required to continually improve their national greenhouse gas inventory. As new information and data become available and more accurate methods are developed, previous estimates are updated to provide a consistent and comparable trend in emissions and removals. On a continuous basis, Environment Canada consults and works jointly with key federal and provincial partners along with industry stakeholders, research centres and consultants to improve the quality of the underlying variables and scientific information for use in the compilation of the national inventory. Where necessary, Environment Canada revises and recalculates the emission and removal estimates for all years in the inventory. This work is carried out as part of continuous improvement efforts to integrate refined data or methods, incorporate new information or additional sources and sinks, implement any new guidance, and correct errors and omissions. Recalculations can be triggered by a change in methodology, emission factor or parameter, by an update in activity data or by the addition of a new category. Changes are a consequence of the selection of appropriate methods and parameters, and the collection of activity data and will in many cases be the end result of a quality analysis. Rationale for recalculation and impacts on emission levels and trends are documented each year in Chapter 9 of the National Inventory Report.

### 3.5.4 Quality Assurance and Quality Control

Quality Assurance (QA) and Quality Control (QC) procedures are an integral part of the inventory development and submission processes. These procedures ensure that Canada is able to meet the UNFCCC requirements of transparency, consistency, comparability, completeness, and accuracy. The Government of Canada is committed to improving data and methods in collaboration with industry, provinces and territories, academia, and the international community to ensure that a credible and defensible inventory is developed, meeting its international obligations.

Canada's QA/QC plan incorporates a system of continuous improvement that includes, but is not limited to, procedures to capture lessons learned as part of the inventory cycle; using QA/QC and other tools as a means to identify and prioritize improvements; and, processes to ensure that improvements identified are incorporated into the operating procedures.

The plan also includes a schedule for multi-year implementation, such that in every submission year all key categories (and categories where a significant methodological change has occurred) will be subject to Tier 1 QC and over a 3 year cycle all categories will undergo a Tier 1 QC. Some Tier 2 QC, QA and verification activities will be performed every year based on a multi-year schedule with the objective to provide more comprehensive quality assessments of the entire inventory over a seven year timeframe. The implementation of the multi-year cycle is expected to ramp up over the next few years. Until this objective can be met, annual interim targets are set each year by a Prioritization and Planning Committee. In addition, the committee is responsible to approve the implementation of methodological changes, ensuring adequate resources and application of due diligence. Documentation of QA/QC procedures is at the core of the system. Standard checklists are used for the consistent, systematic documentation of all QA/QC activities in the annual inventory preparation and submission. QC checks are completed during each annual inventory preparation and archived along with other procedural and methodological documentation, by inventory category and by submission year. The plan requires the coordination of QA/QC activities with outside agencies and organizations providing activity data and/or developing GHG emission and removal estimates for Environment Canada.

## 3.6 National Registry

Canada has established a national registry that meets the functional requirements of Article 7 of the Kyoto Protocol and the Data Exchange Standards. All testing of Canada's national registry has been successfully completed. The "Readiness Questionnaire" and supporting documentation was submitted to the ITL service desk on 4 June 2008.

As noted in Canada's Independent Assessment Report dated June 12, 2008 Canada's Kyoto Protocol National Registry conforms to the requirements of the data exchange standards and was deemed sufficiently compliant with 13/CMP.1 and 5/CMP.1. The detailed Independent Assessment Report is available online at: http://unfccc.int/resource/docs/2008/iar/can01.pdf.

The name and contact information of the registry

administrators designated by Canada to maintain the national registry are:

**Environment Canada, Legislative and Regulatory Affairs Division**

Primary Contact
Head, Tracking Systems
Environment Canada Trading Regimes Division
819-953-5955
351 St. Joseph Blvd.
Gatineau, Quebec
K1A 0H3

Secondary Contact
Director, Scientific Information Technology Solutions
Environment Canada Chief Information Officer Branch
819-997-1856
10 Wellington St.
Gatineau, Quebec
K1A 0H3

In accordance with Decision 15/CMP.1 and article 7 of the Kyoto Protocol, Canada's Kyoto Protocol National Registry maintains its national registry as a stand-alone system, and does not maintain a system that is consolidated with other national registries.

### 3.6.1 Database Structure and Capacity

Canada's Kyoto Protocol National Registry is constructed as a relational database. In addition to registry core data related to national and legal entity accounts, transactions and user roles, the database contains stored procedures, views and application configuration information that form the major portion of the Canada's Kyoto Protocol National Registry business logic.

Canada's Kyoto Protocol National Registry database management system operates within a shared infrastructure environment of Environment Canada that comprises clustered Microsoft SQL 2005 servers. These servers are attached to a storage area network (SAN) consisting of redundant array of independent disks (RAID) storage devices for reliability and built-in automated fault-tolerance. Data storage capacity for Canada's Kyoto Protocol National Registry can be augmented by adding physical hard drives to the SAN as necessary.

User access to Canada's Kyoto Protocol National Registry is accomplished via two Web application servers operating in a load-balancing mode to prevent overloading of a single Web server. As user loads increase, additional servers can be added to the load-balancing infrastructure.

Existing server hardware is replaced on a four-year cycle and augmented based on forecast demand. Forecast demand is determined as a result of new or updated application system requirements.

The Environment Canada software infrastructure is kept current. This means that major software components of the infrastructure are upgraded within one to two years after a major product release. Emergency patches are implemented on an as-needed basis.

### 3.6.2 Standards

Canada's Kyoto Protocol National Registry includes functionality to perform reconciliation with the international transaction log (ITL), data logging requirements, issuance, conversion, retirement, external transfer, cancellation, replacement, retirement, carry-over, expiry date change, internal transfer between holding accounts and all other functionality required by the Data Exchange Standards V 1.1.

Interoperability testing of Canada's Kyoto Protocol National Registry in accordance with DES Annex H was successfully completed on May 29, 2008. The successful completion of this testing demonstrates that Canada's Kyoto Protocol National Registry operates in a manner that is accurate, transparent, efficient and consistent with Decision 13/CMP.1 and Article 7, paragraph 4 of the Kyoto Protocol.

Canada's Kyoto Protocol National Registry successfully completed the coordinated testing of the standard electronic format functionality in December 2008.

### 3.6.3 Procedures

Before any transaction is processed, Canada's Kyoto Protocol National Registry provides users with a summary of the proposed transaction or activity. The operators are then required to enter their password to certify their decision to proceed with the transaction or activity.

In addition, the application prevents operators from proposing many transaction types that are prohibited by the data exchange standards. For example, the application will only allow ICERs affected by a type 4 reversal of storage to be transferred to the Mandatory Cancellation Account. Any other proposed transaction involving the affected ICERs would not be submitted to the ITL, and the user would be notified of the reason for not submitting the transaction to the ITL. Another example of these internal checks is that no transaction would be submitted to the ITL if the transaction would reduce the holdings of Canada's Kyoto Protocol National Registry below Canada's commitment period reserve level.

Canada's Kyoto Protocol National Registry includes rollback functionality that allows the registry administrator to terminate and reverse transactions when notified to do so by the ITL. This process and any other manual intervention process are implemented through a structured process in Canada's Kyoto Protocol National Registry Web interface. All manual intervention actions are automatically logged by the registry software.

### 3.6.4 Security Measures

#### Physical Security

- Access to the building housing Canada's Kyoto Protocol National Registry is only permitted to persons holding a valid security pass.
- Twenty-four hour security is provided for the building.
- All core equipment hosting Canada's Kyoto Protocol National Registry is housed in a single air-conditioned server room.
- Access to the area is restricted via coded door locks to IT operations staff for the purpose of equipment maintenance.
- The server room is protected against fire by an automated fire-suppression system.
- All Canada's Kyoto Protocol National Registry-related data communications entering and exiting the server room are encrypted.

The following registry-related equipment is stored in the secured area:

- virtual private network (VPN)
- communications switches
- Web server load-balancing devices,;
- Web servers
- application servers
- database servers
- storage area network (SAN)
- all cabling connecting above devices

#### Data Security

- All Environment Canada database servers, including those hosting Canada's Kyoto Protocol National Registry, are protected by an internal hardware-based firewall.
- Communication between Canada's Kyoto Protocol National Registry and the ITL is encrypted using an ITL-approved digital certificate.
- Communications between Canada's Kyoto Protocol National Registry users and Canada's Kyoto Protocol National Registry application server is encrypted using a digital certificate.
- Anti-virus software is installed to protect the Environment Canada shared infrastructure. Anti-virus updates are installed as required.
- Access to Canada's Kyoto Protocol National Registry is permitted only to registered and authorized users. Each user of Canada's Kyoto Protocol National Registry is required to use a user id and password combination to gain access to Canada's Kyoto Protocol National Registry. The password is known only to the user. User authentication is augmented by the use of a digital certificate.
- The composition of passwords for the production version of the registry will meet the following requirements:
    1. Passwords must contain minimum of 8 characters.
    2. Passwords must include at least three of the following four:
        - uppercase
        - lowercase
        - numbers
        - keyboard characters.
    3. Passwords must be replaced every 180 days.
    4. The last 10 passwords may not be reused.

#### Prevention of Operator Error

To prevent operator error before any transaction is processed, the application provides operators with a summary of the proposed transaction or activity. Operators are then required to enter their password to certify their wish to proceed with the transaction or activity.

In addition, the application will not allow an operator to propose any transactions that are not permitted by the data exchange standards. For example, the

application will only allow ICERs affected by a type 4 reversal of storage notification to be transferred to the Mandatory Cancellation Account; any other proposed transaction (e.g. transfer to another national registry) would not be submitted to the ITL and the user would be notified why the transaction was not sent to the ITL.

#### Audit Log

All database manipulation actions by users are captured in an Audit Log. The Audit Log records the following information:

- the identity of the user making the change
- the date and time of the change
- the field being changed
- the old and new values of the field

### 3.6.5 Public Information

The following information has been publicly accessible since Canada's Kyoto Protocol National Registry began live operation with the ITL:

- Account information as required by paragraph 45, Annex, Decision 13/CMP.1
- Article 6 project information as required by paragraph 46, Annex, Decision 13/CMP.1
- Kyoto units' information as required by paragraph 47, Annex, Decision 13/CMP1 (this information will be published with a delay of at least one calendar year)
- Legal entities information as required by paragraph 48, Annex, Decision 13/CMP.1

The Internet address of the interface to Canada's National Registry is http://www.ec.gc.ca/rncpk-ckpnr/.

### 3.6.6 Backup Measures

#### Component Failure

Canada's Kyoto Protocol National Registry operates in a "fail-over" mode. This is accomplished with the following four (4) mechanisms:

**Redundant Web and application servers** Canada's Kyoto Protocol National Registry application and Web services are hosted in a load balancing environment comprised of two independent servers. If one server fails, application transactions are automatically transferred to the other server.

**Redundant database servers** Canada's Kyoto Protocol National Registry database operates within a cluster of two (2) database servers. More can be added if additional capacity or redundancy is required. If one server fails, database transaction processing is automatically transferred to the second server.

**Storage area network** The CKPNR database cluster stores Canada's Kyoto Protocol National Registry data on a storage area network. The database servers are connected to the storage area network using redundant fabric switches. The storage area network utilizes redundant array of independent disks (RAID) technology to ensure that data loss as a result of disk failure is automatically recovered.

**Power failure** All components housing Canada's Kyoto Protocol National Registry operate from a standard grid power supply. In the event of a power failure, a battery-driven uninterruptable power supply (UPS) is automatically engaged, followed by a standby diesel power generator that will provide uninterrupted electricity for a maximum of sixteen (16) hours. Each database server power supply is connected to redundant UPS devices.

#### Network Server Data Backup

As previously stated, Canada's Kyoto Protocol National Registry is hosted within an Environment Canada shared infrastructure. Standard operational doctrine is to perform daily "incremental" backups and weekly "full" backups of all application and database servers. In addition to server backups, the database maintains a separate hourly transaction log.

#### Backup Data Retention

Incremental Backup Data is retained for 30 days, after which it is recycled.

#### Data Recovery

Restoration of data will be accomplished by restoring the appropriate "full" and "incremental" backups, followed by the restoration of database transactions up to the point of failure.

### Disaster Recovery

Canada's Kyoto Protocol National Registry is currently in production but is not available to public users.

Disaster recovery operations comprise:

- restoration of data from full or incremental backup media if necessary;
- use of a secondary site in the event that the primary site is rendered inoperable. The secondary site duplicates the essential functions and characteristics of the primary site. Switch-over from the primary site to the secondary site was successfully tested in November 2009.

## 3.6.7 Testing

Connectivity testing: virtual private network (VPN) testing was successfully completed on January 25, 2008.

Secure socket layer (SSL) testing was successfully completed on May 9, 2008. Environment Canada formal user acceptance testing of Canada's Kyoto Protocol National Registry functionality was successfully completed May 28, 2008. Interoperability testing (DES annex H) was successfully completed on May 29, 2008. The results of connectivity testing and interoperability testing are summarized in the Independent Assessment Report of Canada's National Registry (FCCC/IAR/36 E). Canada's Kyoto Protocol National Registry also successfully completed the coordinated standard electronic format testing that took place during December 2008.

## 3.7 References

Environment Canada, 2009. Canada's National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2007, April 2006. Web link: www.ec.gc.ca/pdb/ghg/.

Statistics Canada. Demographic Statistics. 1990-2000 (Annual). #91-213-XIB.

Statistics Canada. Demographic Statistics. 2001-2007 (Annual). #91-215-X.

Statistics Canada. 2009. Report on Energy Supply-Demand in Canada (Annual). #57-003-XIB.

Statistics Canada. 2008, Provincial and Territorial Economic Accounts Review: Semi-Annual, Catalogue No. 13-016-XWE

United Nations Framework Convention on Climate Change (UNFCCC). 2007. National Greenhouse Gas Inventory Data for the Period 1990-2006, United Nations Framework Convention on Climate Change, FCCC/SBI/2008/12. Available online at: http://unfccc.int/ghg_data/ghg_data_unfccc/time_series_annex_i/items/3814.php

# Chapter 4

# Policies and Measures

## 4.1 Introduction

Canada is committed to tackling climate change through sustained action to build a low-carbon economy. In the 2006 to April, 2009 reporting period covered by this report, Canada implemented a suite of policies and measures to address its domestic GHG emissions. In addition to measures implemented by Canada's provinces and territories, the key national policies and measures described in this report include:

**Clean electricity:** Canada has set a national goal of producing 90% of its electricity needs without emitting GHGs by 2020. Achieving this goal will require increased energy efficiency, fuel-switching away from coal, and expanded use of nuclear and renewable power such as hydro and wind. Governments in Canada are providing significant incentives to increase Canada's supply of clean electricity from renewable sources.

**Energy efficiency:** Canada is amending energy efficiency regulations under the Energy Efficiency Act to introduce new performance standards on products accounting for 80% of the energy used in homes and businesses in Canada. Governments in Canada are also implementing a wide range of energy efficiency programs for consumers and businesses, and exploring the potential of smart grids.

**Carbon Capture and Storage:** In addition to regulatory measures that will promote implementation of CCS, Governments in Canada are investing over $3 billion to support the development, demonstration and deployment of commercial-scale CCS between now and 2015.

**Vehicle emissions:** new national regulatory tailpipe GHG emission standards for new cars and light trucks will reduce average fuel consumption and $CO_2$ emissions from new vehicles of the 2016 model year by 20%. These standards will be phased-in beginning with the 2011 model year and will be aligned with U.S. national standards.

**Renewable fuels:** national renewable fuels standard will require an average annual renewable fuel content of at least 5%, effective in 2010, and an average 2% renewable fuel content in diesel fuel and heating oil by 2011 or earlier, subject to technical feasibility. Canada is also investing $500 million to support the establishment of commercial scale demonstration facilities for the production of next-generation renewable fuels.

Since 2006, Canada has also been developing a comprehensive, market-based regulatory regime for GHG emissions from major industrial sources. In 2009 Canada indicated its intention to review this proposed regime to align it with the emerging cap and trade program in the United States. Aligning our climate change policies and measures with those of the US is a critical element of Canada's overall approach, in light of the close integration of our two economies and our geographic proximity.

As this cap and trade regulatory regime was not finalized during the 2006 to April 2009 period covered by this communication, this Chapter does not describe it.

## 4.2 Description of the Overall Policy Making Process

The Minister of the Environment is the lead minister for domestic and international climate change policies. The other principal federal departments involved in the implementation of federal domestic climate change policies and measures are:

- Natural Resources Canada
- Transport Canada
- Health Canada
- Indian and Northern Affairs Canada
- Agriculture and Agri-Food Canada
- Industry Canada
- Parks Canada

In addition, the Department of Foreign Affairs and International Trade, and the Canadian International Development Agency are involved in supporting Canada's international climate change efforts.

## 4.3 Description of Inter-Ministerial Decision-Making Bodies

### 4.3.1 Federal / Provincial / Territorial

Canada is a federal state; federalism is a structure of government that offers the benefits of political and economic union combined with local autonomy. Decision-making powers are divided between and shared among the federal and provincial governments under the Constitution.

It is within this context that Canadian federal, provincial and territorial governments have adopted action plans to fight against climate change. These plans include legislative and regulatory measures, tax measures, fiscal mechanisms, incentives to reduce GHG emissions, as well as measures to address climate change impacts and adaptation.

Occasionally, First Ministers (Provincial Premiers and the Prime Minister) will meet. These are high-profile sessions around a major national issue–e.g. the Constitution, major economic or security issues. More often there will be meetings of all ministers with common interests, e.g. all Health Ministers, or all Environment ministers, to discuss common issues and come to common solutions. All such meetings are preceded by lengthy discussions among departmental officials.

Most federal departments have direct links with their counterparts in provinces or with provincial departments with related interests. Federal-provincial meetings on technical matters happen throughout the year at all levels – working level through to political.

### 4.3.2 Canadian Council of Ministers of the Environment (CCME)

The main federal/provincial/territorial body addressing national environmental issues is CCME. CCME is comprised of the environment ministers from the federal, provincial and territorial governments. These 14 ministers normally meet at least once a year to discuss national environmental priorities and determine work to be carried out under the auspices of CCME. The Council seeks to achieve positive environmental results, focusing on issues that are national in scope and that require collective attention by a number of governments. Ministers set the strategic direction for the Council, setting out the broad outcomes they seek to achieve. In response, senior officials establish working groups of experts from the federal, provincial, and territorial environmental ministries to accomplish specific goals, with the support of a permanent secretariat. In most cases, group membership may include experts from other relevant government departments (such as Health). Decisions made by the CCME result in the development and implementation, by each of the member governments, of the policies, programs or measures they have drawn up.

### 4.3.3 Canadian Council of Forest Ministers (CCFM)

There has been a long tradition of cooperation between the federal and provincial governments in forestry matters. The creation of the Canadian Council of Forest Ministers (CCFM) in 1985 has provided an important forum for the federal, provincial and territorial governments responsible for forests to work cooperatively to address major areas of common interest. CCFM is comprised of the forest ministers from the federal, provincial and territorial governments. These 14 ministers normally meet at least once a year to provide leadership on intergovernmental and international issues and set direction for the stewardship and sustainable management of Canada's forests. At the request of provincial and territorial premiers, the CCFM's Climate Change Task Force initiated work on a collaborative adaptation strategy for Canada's forest sector. This work included the development a framework for forest management offset protocols for carbon, as well as an assessment of the vulnerability of Canada's trees species to climate change and management options for adaptation. A second phase of this latter work has begun focusing on understanding forest ecosystem and forest sector vulnerability to climate change and potential adaptation measures.

### 4.3.4 Canadian Council of Energy Ministers (CEM)

Intergovernmental cooperation in the resource development sector spans a long history, through the Federal-Provincial-Territorial Council of Energy Ministers and the Mines Ministers' Conference. In recent years, Federal-Provincial-Territorial Council of Energy Ministers and the Mines Ministers' Conference have merged under the banner of The Energy and Mines Ministers' Conference. These annual meetings provide a forum to announce program successes, to discuss emerging issues in mining and energy, and offer an opportunity to explore new partnerships and take collaborative action if appropriate. The Climate Change Adaptation Working Group, established in 2007, has engaged in priority collaborative climate change adaptation initiatives for the energy sector. Its mandate is to continue building the

adaptation knowledge base, facilitate technology transfer and networking, and to make adaptation activities as inclusive as possible.

## 4.4 Description of system which monitors GHG mitigation Policies and Measures progress

Under the Kyoto Protocol Implementation Act (KPIA), the Government of Canada is required to prepare an annual Climate Change Plan to prepare a statement on GHG emissions, and to ensure that Canada meets its obligations under the Kyoto Protocol. The Government of Canada is also required to provide information on the effects of policies and measures to reduce greenhouse gas emissions in Canada. This information includes:

(i) the date on which it came into effect, and

(ii) the amount of greenhouse gas emission reductions that have resulted or are expected to result for each year up to and including 2012, compared to the levels in the most recently available emission inventory for Canada.

## 4.5 Federal Policies and Measures

### 4.5.1 Chronology

In the **April 4, 2006** Speech from the Throne, the Government committed to taking measures to achieve tangible improvements in our environment, including reductions in pollution and greenhouse gas emissions. The government committed $1.7 billion to the Clean Air Agenda from Budget 2005 funding, consisting of the *Clean Air Regulatory Agenda* and the non-regulatory *Program Measures in Support of the Government's Clean Air Agenda*.

In Budget 2006, tabled on **May 2, 2006**, the Government introduced the Public Transit Tax Credit, a tax credit for the purchase of monthly transit passes. Budget 2006 also the extended accelerated capital cost allowance incentive for clean energy generation equipment to additional applications involving cogeneration in the pulp and paper sector.

On **October 21, 2006** the Government issued a Notice of intent to develop and implement regulations and other measures to reduce air emissions. A key commitment in that Notice of Intent was to develop an approach to regulate industrial greenhouse gas and air pollutant emissions.

Following up on that commitment, the Government unveiled its Turning the Corner plan to reduce greenhouse gases and air pollution, on **April 26, 2007**. This plan sets out the approach for reducing greenhouse gas and air pollution emissions from industry. It also outlines planned regulatory measures to reduce emissions from the transportation sector, actions on consumer and commercial products, and actions to improve indoor air quality. Throughout **early 2007**, the Government of Canada unveiled the programming details of its $1.9 billion Clean Air Agenda through a series of announcements. The Clean Air Agenda supports clean energy and clean transportation initiatives through the ecoACTION programs, as well as efforts on climate change adaptation and regulating energy efficiency and greenhouse gas emissions.

On **July 5, 2007**, Prime Minister Stephen Harper announced the ecoENERGY for Biofuels Initiative, which will invest up to $1.5 billion over 9 years to boost Canada's production of biofuels.

On **October 30, 2007** the Government tabled Budget 2007. Budget 2007 included new funding and a rebalancing of tax incentives that further encouraged investments in cleaner energy, spurred technological innovation for the more sustainable use of traditional energy sources, made the most of our clean energy resources and promoted energy efficiency. Budget 2007 invested $4.5 billion to clean our air and water, to reduce greenhouse gases and combat climate change, as well as to protect our natural environment. Combined with investments since 2006, totalling over $4.7 billion, the resulting investments totalled over $9 billion.

Budget 2007 included:

- Providing over $1.5 billion in the Canada ecoTrust for Clean Air and Climate Change to support major environmental projects with provinces and territories;
- Committing to identifying additional measures to promote promising new clean energy technologies like carbon capture and storage;
- Phasing out the accelerated capital cost allowance for general investment in the oil sands by 2015;
- An additional $2 billion over seven years to support the production of renewable fuels, including a $1.5-billion incentive to support the production of renewable biofuels, such as ethanol and biodiesel;
- $500 million for Sustainable Development Technology Canada to invest with the private sector in establishing large-scale facilities for the production of next-generation renewable fuels;

- A Vehicle Efficiency Incentive structure that included a new rebate of up to $2,000 for the purchase of a new fuel-efficient vehicle, and a Green Levy on new fuel-inefficient vehicles;
- $36 million over two years for "scrappage"programs to retire older vehicles; and
- Extending the public transit tax credit to electronic fare cards and weekly passes when used on an ongoing basis.
- Extending the accelerated capital cost allowance incentive for clean energy generation equipment to equipment acquired before 2020 and expanding the incentive to include wave and tidal energy, and additional solar and waste-to-energy applications.
- A further $350 million for Sustainable Development Technology Canada to invest in clean air and climate change projects;

On **December 3, 2007**, the Government officially announced details and eligibility requirements for the ecoENERGY for Biofuels program, which supports the production of renewable alternatives to gasoline and diesel and encourages the development of a competitive domestic industry for renewable fuels. Recipients will be entitled to receive incentives for no more than seven consecutive years. The program runs from April 1, 2008 to March 31, 2017.

On **December 12, 2007**, the Government of Canada formally required industry to provide information about their emissions of air pollutants and greenhouse gases. This information will be used to inform the drafting of regulations in 2010.

On **February 26, 2008** the Government tabled Budget 2008. In Budget 2008, the government announced GST/HST relief for land leased for wind or solar electrical power projects.

Budget 2008 included:

- Regulating new energy efficiency of 20 currently unregulated products such as commercial clothes washers and commercial boilers; and
- Tightening requirements for ten products, such as residential dishwashers and dehumidifiers.
- Expanding the accelerated capital cost allowance for clean energy generation equipment to additional applications involving ground source heat pump and waste-to-energy applications.
- Providing GST/HST relief for land leased for wind or solar electrical power projects.

On **March 10, 2008**, the Government announced further details of the greenhouse gas emissions regulations of the Turning the Corner plan, after extensive consultations with environmental groups, industry and other stakeholders.

On **June 29, 2008** the Government launched the Credit for Early Action Program. The objective of the Program is to recognize facilities that took verified early action to reduce greenhouse gases between 1992 and 2006. The purpose is to address the disadvantage that a facility could incur for having undertaken an incremental action to reduce greenhouse gases before the proposed regulatory regime was set out.

On **August 9, 2008** the Government published details of Canada's Offset System, an important component of Canada's climate change plan designed to help achieve the targets in reducing greenhouse gas emissions and to generate real emission reduction opportunities across the economy. The Offset System will issue offset credits for eligible project-based greenhouse gas reductions and removals.

On **November 19, 2008** in the Speech from the Throne, the Government announced its commitment to work with provincial and territorial governments, as well as other partners, to develop and implement a North America-wide cap and trade system for greenhouse gases.

On **January 27, 2009** Budget 2009 launched Canada's Economic Action Plan. Budget 2009 included actions to ensure a healthy environment, including:

- A new Clean Energy Fund that supports clean energy research development and demonstration projects, including carbon capture and storage;
- Improving the Government's annual reporting on key environmental indicators such as clean air, clean water and greenhouse gas emissions with $10 million in 2009–10; and
- Strengthening Canada's nuclear advantage with $351 million to Atomic Energy of Canada Limited for its operations, including the development of the Advanced CANDU Reactor, and to maintain safe and reliable operations at the Chalk River Laboratories.

Ensuring the adoption of clean energy technologies is critical to meeting these targets and, as such, is a key focus of the Government of Canada. The $1 billion Clean Energy Fund introduced as part of Canada's Economic Action Plan will complement the efforts of Canada's provinces and territories to enhance our ability to make use of the country's vast energy reserves without harming the environment. As another part of the Government of Canada's Economic Action Plan, the

ecoENERGY Retrofit – Homes program was expanded to help 200,000 more homeowners cover the cost of making energy-efficiency retrofits to their homes. The expanded time-limited program includes a $300-million increase in funding over two years.

In **February 19, 2009**, Prime Minister Harper and President Obama agreed to begin a Canada – US Clean Energy Dialogue (CED), the most significant development in continental, environmental and energy policy since the North American Free Trade Agreement. The Clean Energy Dialogue focuses on three critical areas: expanding clean energy research and development; developing and deploying clean energy technology, especially carbon capture and storage; and, building a more efficient electricity grid based on clean and renewable generation. Canada is committed to tackling climate change through sustained action to build a low-carbon economy that includes reaching a global agreement, working with our North American partners and taking action domestically.

On **April 1, 2009**, the Government of Canada announced that it will introduce new regulations to limit greenhouse gas emissions from the automotive sector under the Canadian Environmental Protection Act, 1999 (CEPA). In keeping with the Government of Canada's commitment to put these regulations in place for 2011 model year vehicles, the Government will proceed immediately to put regulations in place under CEPA. By taking this approach, the Government of Canada will have the flexibility to harmonize its regulations with the broad range of possible future actions from the U.S. government to address greenhouse gas emissions from vehicles.

## 4.5.2 Federal Sectoral Policies and Measures

### 4.5.2.1 Energy Policies and Measures

Since January 2007, the Government of Canada has announced several measures related to clean energy, including:

**ecoENERGY for Biofuels Initiative** supports the production of renewable alternatives to gasoline and diesel and encourages the development of a competitive domestic industry for renewable fuels. Through the initiative, the Government will invest up to $1.5 billion over nine years in support of biofuels production in Canada by partially offsetting the investment risks associated with fluctuating feedstock and fuel prices. In fiscal year 2008/09, the program signed 22 contribution agreements representing a total commitment of $938 million and a volume of 1.63 billion litres of biofuels..

**ecoENERGY for Renewable Power** program is investing $1.46 billion to provide incentives to provide incentives to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, low impact hydro, geothermal, solar photovoltaic, and ocean energy. The program will provide an incentive of 1cent/kWh for up to 10 years to qualifying projects. As of March 31, 2009, 52 contribution agreements had been signed with proponents, representing about $900 million in federal funding over 10 years and more than 2700 MW of renewable power capacity.

**ecoENERGY Technology Initiative (ecoETI)** is investing $230 million over five years (2007-12) in the research, development and demonstration of clean transformational energy technologies and systems. Given the longer term nature of the projects supported by the ecoETI program, the investment is expected to lead to reductions in greenhouse gas emissions in the post-2012 period. The Initiative is directed towards increasing clean energy supplies, reducing energy waste and reducing pollution from conventional energy.

**ecoENERGY for Renewable Heat** initiative is investing approximately $36 million over four years in incentives and industry development to support the adoption of clean renewable thermal technologies such as solar air and solar hot water for water and space heating in buildings. The program achieves GHG reductions by encouraging individuals and organizations to use renewable solar thermal systems.

**ecoENERGY for Buildings and Houses** program is investing $60 million over four years to encourage the construction and operation of more energy-efficient buildings and houses through a range of complementary activities such as rating, labeling and training.

**ecoENERGY Retrofit Initiative** provides incentives for energy efficiency improvements in homes and in small and medium-sized organizations in the institutional, commercial and industrial sectors. The ecoENERGY Retrofit – Homes component provides home and property owners with grants up to $5,000 per unit to offset the cost of making energy efficiency improvements. The Retrofit – Homes program involves residential energy efficiency assessments by certified energy advisors

and is complemented by a suite of provincial programs. An additional $300 million was allocated to the ecoENERGY Retrofit for Homes program through the 2009 Canada's Economic Action Plan, bringing the total budget for this element to $460 million over four years. The ecoENERGY Retrofit - Small and Medium Organizations ($40 million over five years) component provides financial incentives to facilities meeting specified criteria based on the estimated amount of energy saved by retrofit activities.

**ecoENERGY for Industry** program is investing $18 million over four years to encourage information-sharing on new technologies and best practices in energy use, as well as training and specialized assessments for energy managers to identify and implement energy-saving projects. The program is an industry-government partnership delivered through the Canadian Industry Program for Energy Conservation (CIPEC). CIPEC encourages industrial energy efficiency improvements and reductions in GHG emissions through a number of voluntary activities.

**A regulatory agenda** ($32 million), under the authority of the Energy Efficiency Act, will introduce or raise energy efficiency standards for a wide range of energy-using products. As a result, 80 percent of the energy used in homes and businesses will soon be regulated. Stricter regulations mean that, over time, inefficient products will disappear from the marketplace.

**Canada provides two tax incentives** to promote investment in clean energy generation equipment that uses renewable energy, energy from waste (e.g. landfill gas, wood waste), or fossil fuels in a highly efficient manner. Accelerated capital cost allowance (CCA) is provided for such investments under CCA Class 43.2 and the Canadian Renewable and Conservation Expense provision allows certain intangible start-up expenses associated with Class 43.2 projects to be deducted in full in the year incurred or transferred to investors using flow-through shares.

**Budget 2006** extended Class 43.2 to include assets acquired before 2020. In addition, Budgets 2006, 2007 and 2008 collectively expanded Class 43.2 to include wave and tidal energy, space and water heating using ground source heat pumps and solar thermal energy, and a range of additional waste-to-energy applications.

**In Budget 2007,** the Government of Canada announced the phase-out of the accelerated capital cost allowance (CCA) for general investment in oil sands projects over the 2011-2015 period. This provision provides a financial benefit by deferring taxation until the cost of capital assets has been recovered out of project earnings. Removal of the incentive will improve fairness and neutrality among the oil sands and other sectors.

The Government of Canada has introduced two tax incentives designed to encourage energy-efficient transportation options.

**The Public Transit Tax Credit** introduced in 2006, allows individuals to claim a non-refundable tax credit for the cost of monthly public transit passes or passes of a longer duration, or electronic fare cards and weekly passes when used on an ongoing basis.

**The Green Levy** introduced in 2007, encourages the purchase of fuel-efficient vehicles in Canada. The Levy applies to new automobiles designed primarily to carry passengers, in accordance with the vehicle's fuel-efficiency rating. Vehicles with a combined fuel-efficiency rating (55 per cent city and 45 per cent highway) of 13 or more litres per 100 kilometres are subject to the levy at rates ranging from $1,000 to $4,000. The Green Levy is payable by the manufacturer or importer at the time the vehicles are delivered to a purchaser (usually a dealer) or imported.

**ecoENERGY for Aboriginal and Northern Communities** program is investing $15 million over fours years in Aboriginal and Northern Communities, including the approximately 130 remote communities that rely on diesel power generation, to improve energy efficiency and adopt alternative energy sources to reduce dependence on diesel fuel. The program will assist communities through all stages of project development, including project identification and inception, feasibility and planning studies, financial and project management, equity partnerships, power purchase agreements and project completion.

### EcoAction Community Funding Program

Environment Canada's EcoAction Community Funding Program provides financial support to non-profit community groups for projects that produce measurable,

positive impacts on the environment. EcoAction encourages action focus projects that will protect, rehabilitate or enhance the environment, and build the capacity of communities and individuals to sustain these activities into the future. The program supports projects that reflect Environment Canada priorities: reduction of greenhouse gas emissions, improvements in air and water quality and protection of species and their habitat.

Clean renewable energy projects could potentially be eligible for funding under EcoAction's climate change category. For example, the Halton Solar project will conduct 150 home energy audits and install a minimum of 50 solar panel systems. The Halton Environmental Network will also provide education and outreach to homeowners in Halton Region on the benefits of solar panel installations.

Eligible recipients for program funding include non-profit, non-government organizations. Recipients must secure 50% matching funds from non-government sources. Maximum EcoAction contribution is $100,000 per project for a maximum duration of 2 years. Projects must produce measurable environmental results.

### 4.5.2.2 Transport Policies and Measures

The **ecoTRANSPORT** Strategy is part of the Government of Canada's ambitious agenda to protect our environment and the health of Canadians and to further economic prosperity. Initiatives announced to date include the following:

The **ecoFREIGHT** Program is aimed at reducing the environmental and health effects of freight transportation through the use of technology. The program is investing $61million over four years, and includes six initiatives:

1. National Harmonization Initiative for the Trucking Industry ($6M): identifying regulatory barriers and solutions in collaboration with provinces and territories, so that the Canadian trucking industry can embrace emissions-reducing technologies.

2. Freight Technology Demonstration Fund ($10M): establishing cost-shared demonstrations to test and measure new and underused freight transportation technologies in real-world conditions, and disseminating information to industry.

3. Freight Technology Incentives Program ($10M): providing cost-shared funding to companies and non-profit organizations in freight transportation to help them to purchase and install proven emission-reducing technologies.

4. ecoFREIGHT Partnerships ($7M): building and maintaining partnerships within the transportation sector to reduce emissions from freight transportation through fast and flexible voluntary actions that can support the regulatory framework.

5. Marine Shore Power Program ($6M): a five year program demonstrating the use of shore-based power for marine vessels in Canadian ports to reduce air pollution from idling ship engines in some of Canada's largest urban centres.

6. ecoENERGY for Fleets ($22M): helping commercial fleet and institutional road vehicle operations cut fuel costs and reduce harmful emissions. The ecoENERGY for Fleets Initiative will emphasize information-sharing, workshops and training to help fleets increase their fuel efficiency.

The **ecoMOBILITY** Program aims to reduce emissions from the urban passenger transportation sector by helping municipalities deliver programs, services and policies that attract residents to less polluting forms of transportation. The ecoMobility program is investing $10 million over five years to provide financial support to municipalities and regional transportation authorities for transportation demand management (TDM) projects that demonstrate how municipal initiatives can reduce emissions by shifting personal automobile travel to other modes, reducing the number and length of car trips, and shifting trips to less congested times and routes. The program will help build capacity in municipalities across Canada to implement transportation demand management measures through research, professional development, information sharing and the development of materials / resources.

The **ecoTECHNOLOGY for Vehicles** program is investing $15 million over four years to help to accelerate the adoption of advanced vehicle technologies that reduce greenhouse gas (GHG) emissions and promote a reduction of fuel consumption in the Canadian fleet of light-duty vehicles. This objective is achieved by acquiring and testing emerging environmental light-duty vehicle technologies, informing Canadians about these new technologies through showcasing and publications and working in partnership with industry, consumers, other Government departments and key stakeholders.

The **ecoAUTO Rebate Program** concluded its 2-year mandate on March 31, 2009. It provided a cash incentive to Canadians to help the environment by buying or leasing more fuel-efficient vehicles. Through this initiative, the federal Government offered rebates from $1,000 to $2,000 towards the purchase or lease (12 months or more) of new fuel-efficient vehicles for the model years 2006, 2007 and 2008. Only new eligible

vehicles purchased or leased between March 20, 2007 and December 31, 2008, and for which a rebate application form was received by March 31, 2009, qualified for the rebate.

The **ecoENERGY for Personal Vehicles Initiative** is investing $21 million over four years to provide Canadians with helpful tips and decision-making tools to assist them with buying, driving and maintaining their vehicles in a manner which reduces fuel consumption and greenhouse gas emissions. Such resources include, but are not limited to: the Fuel Consumption Guide; new driver training; and idle-free and tire inflation campaigns.

#### Moving On Sustainable Transportation (MOST)

Transport Canada has established the Moving On Sustainable Transportation (MOST) Program to support projects that produce the community-based education, awareness and analytical tools we need if we are to make sustainable transportation a reality. The MOST Program provides funding to help support projects that stimulate the development of innovative approaches for increasing the sustainability of Canada's transportation system, the use of sustainable modes of transportation, and provide Canadians with practical information for better incorporating sustainable transportation options into their daily lives.

#### National Vehicle Scrappage Program

The Government of Canada has committed $92 million over four years to Clean Air Foundation's Retire Your Ride program to help Canadians recycle their older, higher polluting vehicles and make sustainable transportation choices, leading to reduced air pollution and greenhouse gas emissions. The program also ensures that vehicles are recycled responsibly; thereby further preventing the release of harmful substances into the environment.

### 4.5.2.3 Agriculture, Forestry and Waste Management PAMs

#### Biofuels Capital Initiative

Provides repayable contributions for the construction or expansion of transportation biofuel production facilities. Funding is conditional upon agricultural producer investment in the biofuel projects, and the use of agricultural feedstock to produce the biofuel. 8 projects approved totalling $46M.

#### Biofuels Opportunities for Producers Initiative

Helped farmers and rural communities hire experts to assist in developing business proposals and feasibility and other studies that were necessary to create and expand biofuels production capacity by agricultural producers. Program closed in 2008. $18.7M provided to 120 projects.

#### Agriculture Bioproducts Innovation Program

Seeks to mobilize Canada's creative talent in academia and in the private and public sectors and to integrate resources to build greater research capacity in agricultural bioproducts and bioprocesses. 9 research networks have received funding totalling $68.3M.

#### The National Carbon and Greenhouse Gas Accounting and Verification System (NCGAVS)

NCGAVS provides an increased ability to assess and report on the agricultural sector's environmental performance with respect to soil carbon and greenhouse gases. The purpose of this is to provide and improve the scientific basis for performance measurement and reporting of the Canadian agricultural sector's greenhouse gas footprint.

#### BIMAT – Biomass Inventory Mapping and Analysis Tool

Provides producers of bio-products with the types, quantities and qualities of biomass available by location to make effective use of this material. Accessible over the Internet, it offers interactive queries and thematic maps that can guide users to sources in Canada of precisely the kinds and amounts of feedstocks they need for their processing plants.

### 4.5.2.4 Cross-sectoral PAMs

#### Offsets System

The government has committed to reducing Canada's total greenhouse gas emissions by 20 percent below 2006 levels by 2020. The Offset System is designed to encourage cost-effective domestic reductions or removals in activities or sectors that are not covered by the planned federal greenhouse gas emissions regulations. Projects that satisfy the eligibility criteria can receive offset credits that can be sold in the market.

Offset projects exist across the economy; they could include, for example, methane capture and destruction from landfill gas, reforestation and other forestry projects, and agricultural soil management.

Work on the Offset System design has been under way for a number of years. This work has included extensive consultations with provinces and territories, and with industry and other stakeholders. It builds on the experience from three Canadian emission-reduction pilot programs and from existing international project-based crediting schemes.

The detailed eligibility requirements and application processes are set out in a series of Offset System Program Rules and Guidance documents that have been published in draft form; final versions of these documents are expected to be published in the fall of 2009.

The Offset System is built on the following principles:

1. Environmental benefits - offset projects achieve greenhouse gas reductions and a net environmental benefit.

2. Reductions occur in Canada - greenhouse gas reductions are domestic.

3. Maximum scope - the system promotes projects in as many sectors and for as many project types as practical.

4. Administratively simple - the system is as simple and cost-effective to administer as practical, and the burden for participants is minimized, while still ensuring a rigourous commitment to the environmental integrity of the system.

5. Build on experience - the system builds on the experience gained from the Canadian pilot projects and project-based crediting systems in other jurisdictions.

## 4.6 Description of Provincial Policies and Measures

### 4.6.1 Alberta

In 2007, Alberta passed amendments to the Climate Change Emissions Management Amendment Act to regulate GHG emissions from large industry. As of July 1, 2007, companies that emit more than 100,000 tonnes of $CO_2$– equivalent are required to reduce their emissions intensity by 12%, using an average of 2003 emissions as a baseline. These regulations apply to about 10 facilities that make up about 70% of Alberta's emissions. Compliance options include purchasing offset credits in the Alberta-based offset system and paying into the Climate Change and Emissions Management Fund, which invests in projects and technology to reduce emissions. As of April 2009, Alberta companies had paid approximately $120 million into this fund.

In April 2008, the province announced the establishment of the Alberta Carbon Capture and Storage Development Council to develop a roadmap for implementing carbon capture and storage.

In July 2008, Alberta announced its climate change action plan with two new funds totalling $4 billion to reduce GHG emissions equal to taking more than a million cars off the road each year. The province will create a $2-billion fund to advance carbon capture and storage (CCS) projects while a second $2-billion fund will propel energy-saving public transit in Alberta.

In December 2008, Alberta released its Provincial Energy Strategy which includes actions to:

- address the environmental footprint of energy and encourage the development of renewable energy;

- change energy consumption behaviour by industry and consumers through conservation measures and a review of emissions targets and carbon charges for large industrial facilities;

- improve innovation through increased investment in research, development, demonstration and deployment of energy technology; and

- enhance the capability of the electricity system by planning for a comprehensive upgrade to strengthen the transmission system by identifying requirements, technical solutions, timing, and updating of the approval process.

The province has also committed to 5% ethanol content in gasoline and 2% renewable content in diesel by 2010, and currently purchases 90% green energy for all government buildings.

### 4.6.2 British Columbia

In 2008 British Columbia launched a comprehensive Climate Action Plan to achieve its legislated GHG reduction targets. Key policy measures included in the Plan include:

- A broad-based revenue-neutral carbon tax introduced in 2008 as a core economic policy to support the Province's greenhouse gas reduction targets. The carbon tax is a tax on pollution that cuts personal and corporate income taxes.

    - Under law, every cent of the estimated $2.3 billion collected will be returned to taxpayers through personal, small business and business income tax cuts. Along with other

tax cuts that have been made, individuals in British Columbia now benefit from the lowest provincial income taxes in the country on earnings up to $118,000.

- A legislated commitment for the entire public sector, including schools, universities, colleges and hospitals, to be carbon neutral in 2010.
- A $14-billion Provincial Transit Plan designed to expand transit services to communities to increase ridership and estimated to reduce emissions by 4.7 million tonnes cumulatively by 2020.
- The Pacific Institute for Climate Solutions, a partnership that will bring together leading universities to develop cutting-edge solutions for climate change mitigation and adaptation.

British Columbia's commitment to taking bold action on climate change is enshrined in legislation. To date eight pieces of climate action legislation have been passed:

- Greenhouse Gas Reductions Targets Act: Setting GHG reduction targets for the Province and mandating the provincial government become Carbon Neutral in 2010.
- Cap and Trade Act: Authorizes participation in the Western Climate Initiative. BC is the first Canadian province to introduce such legislation.
- Vehicle Emissions Standards Act: Enabling the adoption of tailpipe emissions standards that will increase automobile fuel efficiency.
- Emissions Standards Statutes Amendment Act: Regulating landfill gas.
- The 2008 Utilities Commission Amendment Act: Designed to encourage more low-carbon energy generation projects.
- Renewable and Low Carbon Fuel Requirements Act: Encouraging the development of renewable forms of energy and decreasing the carbon content of fuels.
- Green Communities Statutes Amendment Act: Designed to guide the development of more sustainable, healthy communities.
- Wood First Act: Requiring provincially-funded building projects use wood as the primary construction material where possible.

British Columbia is playing a leading role in a number of international climate action partnerships:

- British Columbia is among several provinces and states – British Columbia, Manitoba, Ontario, Quebec, Arizona, California, Montana, New Mexico, Oregon, Washington, and Utah – that have partnered in the Western Climate Initiative (WCI). Observers include Saskatchewan and Nova Scotia as well as other US and Mexican states. British Columbia currently co-chairs the WCI with California and also serves as the Canadian Liaison. WCI members have established a regional goal to reduce GHG emissions to 15% below 2005 levels by 2020. This target will lay the foundation for a common cap and trade system, for which design recommendations were released in September 2008. The first phase of the cap-and-trade program will begin on January 1, 2012, with a three-year compliance period.
- British Columbia continues to chair the International Carbon Action Partnership (ICAP) and is on the executive committee of The Climate Registry (TCR). The provinces of Ontario and Quebec are also members of ICAP and all Canadian provinces and territories are members of The Climate Registry.
- British Columbia created the Pacific Coast Collaborative with the other Pacific states as a forum to share experiences and develop common solutions to protect our shared Pacific Ocean.

### Clean Energy in BC

Making the transition to a clean energy economy is a cornerstone of British Columbia's climate action plan. 90 per cent of British Columbia's electricity is already generated from clean and renewable sources.

British Columbia's Energy Plan (2007) includes measures to reduce emissions from the energy sector, such as: requirements for net zero GHG emissions from new electrical power generation (including coal-fired) and from existing thermal power generation by 2016; a target to acquire 50% of incremental resource needs hrough conservation by 2020; and, a $25 million Innovative Clean Energy Fund to encourage commercialization of alternative energy solutions.

In November 2009, Government appointed the Green Energy Advisory Task Force, a panel of clean-energy industry leaders, climate change experts, Crown Corporation representatives and environmentalists, to provide advice on strategies to BC's abundant green energy potential into real economic, environmental and social benefits for British Columbians.

Other clean energy initiatives include:

- Bioenergy Strategy: A vision to advance the development of BC's forestry, agriculture and other biomass resources for electricity, heating, solid, liquid and gaseous fuels to meet growing energy demands and provide economic development opportunities.
- BC Bioenergy Network: Established in March 2008 with $25 million in provincial funding, the BCBN is an industry-led initiative designed to advance bioenergy research and technology development in BC.
- Renewable and Low Carbon Fuel Standards: BC requires 5% ethanol in gasoline and 3% biodiesel in diesel in 2010, rising to 5% by 2012, and a minimum 10% reduction in carbon intensity of passenger vehicles by 2020.
- Solar BC: $5 million to support the expansion of solar thermal energy systems throughout BC.
- Standing Offer Program: BC Hydro offers a simplified open call for renewable energy projects under 10 MW

### 4.6.3 Manitoba

In June 2008, the Manitoba Climate Change and Emissions Reductions Act received royal assent. The initial target is to reduce emissions by 2012, to an amount that is at least 6% less than Manitoba's total 1990 emissions.

Manitoba aims to achieve this goal through initiatives such as:

- Provincial energy saving target of 842 megawatts of electricity by 2017. In addition, the government has committed to developing 1000 megawatts of wind power over the next decade as well as expanding renewable power production through hydroelectric, solar and biomass power production;
- Biofuels legislation mandating 8.5% ethanol in gasoline products, generating an annual reduction of 150 kilo tonnes of GHGs, and reducing Manitoba's overall GHG emissions by 135 kilo tonnes;
- Vehicle Standards Advisory Board established to help determine an efficiency or emissions standard to take effect by 2010, in conjunction with the California standard;
- Development of a new 300 megawatts wind farm, the largest in Canada once completed. The project will displace 800,000 tonnes of greenhouse gas emissions annually;
- Commitment of $3 billion over 10 years for the Clean Energy Transfer Initiative to promote enhancements to the east-west power grid to sell hydro power to other jurisdictions.
- Coal-reduction strategy including a tax on coal emissions, capital support for coal-reliant industries to convert to cleaner energy and support for developing biomass, a coal alternative;
- Expanding energy efficiency through new building codes and standards; programs for homeowners, low-income housing, businesses and farms; and promoting energy efficient appliances;
- Sustainable Agriculture Practices Program aimed at best practices to reduce on-farm GHG emissions including cropping and livestock strategies and wetland restoration incentives.

The Manitoba government will encourage the establishment of agricultural soil sinks, which is expected to provide reductions of 25 megatonnes of $CO_2$ - equivalent by 2012 and 37 megatonnes by 2050. In addition, the reforestation of 20,000 hectares by 2017 is expected to contribute 4.9 megatonnes of reductions.

Manitoba and California signed a Memorandum of Understanding in 2006, agreeing to work together to advance development of hybrid hydrogen vehicles, geothermal technology and credit trading opportunities.

In 2007, Manitoba signed the Midwestern Regional Greenhouse Gas Reduction Accord. The Accord was to complete development of a proposed cap and trade system, and set targets for greenhouse gas emission reductions consistent with the 60-80% recommended by the United Nations Intergovernmental Panel on Climate Change. Full implementation of the accord is to be completed within 30 months.

Manitoba is a member of the Western Climate Initiative with Arizona, California, New Mexico, Oregon, Utah, Montana, Washington, Ontario, Quebec and British Columbia. Members have set a regional GHG emissions reduction target of 15 per cent below 2005 levels by 2020. A cap and trade system will also be developed for industry.

### 4.6.4 New Brunswick

New Brunswick's Air Quality Regulations set the context for all industrial sectors operating in the province and include a strong industrial approvals program which generally incorporates facility level emission caps, as well as monitoring and reporting programs. Industrial approvals are updated every five years, and newer approvals have incorporated a requirement for facilities to

carry out engineering studies to identify opportunities for further emission reductions.

In 2007, New Brunswick commissioned a study on the feasibility of constructing a second nuclear facility at Point Lepreau. The study concluded that the project can be viable and could potentially displace some fossil fuel generation in New Brunswick, Nova Scotia and Prince Edward Island if the transmission issues are resolved.

New Brunswick is a signatory to the New England Governors/Eastern Canadian Premiers Climate Change Action Plan. This plan includes a commitment to reduce regional GHG emissions to 1990 levels by 2010, 10% below 1990 levels by 2020, and recognizes a long term need to require reductions of 75 – 80 %. The plan has identified energy demand, electricity, and transportation as key sectors for emissions reduction.

New Brunswick has signed the Atlantic Energy Framework for Collaboration. This is an agreement designed to increase cooperation on the energy development to produce a more sustainable, reliable, and secure energy supply. This cooperation will be required if the region is to more fully develop its renewable energy resources.

At the June 2007 Shared Air Summit in Toronto, the provincial governments of Ontario and New Brunswick signed an agreement to work together to fight climate change and reduce transboundary air pollution. The Agreement to Reduce Transboundary Air Pollution, Improve Regional Air Quality and Address Climate Change will encourage mutual understanding and cooperation on transboundary air quality impacts and climate change between the two provinces.

### 4.6.5 Newfoundland and Labrador

In 2007, Newfoundland and Labrador released "Focusing our Energy", a comprehensive plan that will guide the energy policy of the province and promote the development of sustainable green energy solutions for the 21st century. It outlines the potential development of the Lower Churchill Project – one of the largest green energy projects in North America today. Once the Lower Churchill Project begins producing power and the transmission link is complete, 98 per cent of Newfoundland and Labrador's energy will come from renewable clean sources, ensuring a reliable, competitively-priced supply of power for development in this province with the surplus exported to markets in North America to assist in the reduction of GHG emissions. The Plan also commits government to setting a provincial emissions reduction target, to updating it 2005 Climate Change Action Plan, to developing a GHG strategy for the energy intensive sector, and to developing an energy efficiency strategy.

The 2005 Climate Change Action Plan contains 40 action items. Highlights include a strategy for government departments to reduce greenhouse gases, such as improved energy efficiency in public buildings; public awareness on climate change issues; research and development initiatives with post-secondary institutions; promoting energy efficiency in public housing; promoting local research initiatives on carbon accounting in forestry management; and working with municipalities to assess vulnerabilities and develop adaptation strategies.

Since 2007, government has set out a number of energy efficiency initiatives. These include residential energy audit and rebate programs, cost shared with the federal government. Through the two electrical utilities, commercial and industrial rebate programs and energy audits are being implemented. These actions will be complemented by new actions in the energy efficiency strategy as committed to in the Energy Plan.

Newfoundland and Labrador are taking action in its energy intensive sectors. For example, through the C-NLOPB, the regulatory agency responsible for overseeing the offshore oil sector, the province has adopted the World Bank's voluntary standard for gas flaring. Additionally the province is looking at new and innovative approaches such as the District Energy System in Corner Brook which will use heat from the city's Kruger newsprint mill to reduce heating costs at Grenfell College of Memorial University and other public and private sector buildings in the area.

Newfoundland and Labrador are providing support to others to reduce GHG emissions in the province. The Newfoundland and Labrador Green Fund is a three year $25M program, cost-shared with the federal government, that supports a wide range of energy and climate change related initiatives. Projects include district heating studies, energy efficiency projects, small scale wind turbines, biofuels, and waste methane capture at the Robin Hood Bay Regional Waste Management Facility in St. John's.

Newfoundland and Labrador are showing leadership. All new public buildings are being constructed to LEED Silver standard, and it is retrofitting public buildings using energy efficient lighting and improved insulation and other energy-saving systems. It its transportation fleet, it committed that 25% of new cars and SUVs purchased would be hybrids. Purchases to date have doubled that commitment (to almost 50%). Within the government structure, it established a new Office of Climate Change, Energy Efficiency and Emissions Trading. This Office, located within the Executive Council, will

provide government with a coordinated and comprehensive approach to climate change and related matters, and will lead strategic development commitments in the Energy Plan.

### 4.6.6 Northwest Territories

Since 2001 when the Northwest Territories (NWT) Greenhouse Gas Strategy was first prepared, the Government of the Northwest Territories (GNWT) has taken a coordinated approach to responding to climate change concerns. Actions taken include steps to control and reduce greenhouse gas emissions and an increasing need to respond to impacts on the environment caused by the warming climate.

Emission mitigation actions were enhanced in 2007 when the NWT Greenhouse Gas Strategy was revised and clearly linked to the territories' Energy Plan. In 2010, the NWT Greenhouse Gas Strategy will undergo a scheduled review and renewal process. In 2008 the GNWT released its Energy Priorities Framework that outlines investments of $CDN 60 million over three years to displace the use of imported diesel fuel for electrical and heat generation and reduce GHG emissions.

Investment are being made to support continuous improvements in energy efficiency for homeowners and communities and upgrades to the energy performance of existing government facilities, New facilities developed by the GNWT are constructed in accordance with the Good Building Practice for Northern Facilities 2009 guidebook so they meet an energy performance benchmark of 25% more efficient than the Model National Energy Code for Buildings 1997.

Use of residual heat recovered from diesel-electric generators in district heating systems is being expanded in communities. New systems are now being installed and will provide opportunities for greater use of biomass heat in future years.

A proposal to construct a transmission line to bring hydro-electricity to remote mines currently fuelled with diesel power is undergoing Environmental Assessment. Run of the river hydro developments are being advanced in two NWT communities. The GNWT is preparing a Hydro Strategy to provide a strategic long-term approach for future hydro-electric developments.

Investments in wood pellet technologies have provided cost-effective alternatives to replace diesel fired heat for large institutional buildings. A Biomass Energy Strategy now being finalized will guide further use of biomass energy in buildings and district heat systems including the generation of electricity. This Strategy also addresses sustainability of forest harvest practices.

The GNWT is working with local Aboriginal Development Corporations to install wind-diesel systems in small remote communities. The first project will be three 100 kilowatt turbines installed in Tuktoyaktuk in 2011.

Energy planning in all communities is supported by the GNWT. Some, like the City of Yellowknife have already adopted their own emission targets and are well into implementation.

### 4.6.7 Nova Scotia

Nova Scotia's key initiatives to meet its emission reduction targets include:

- a mandatory declining cap on GHG emissions from Nova Scotia Power, which is regulated under the Environmental Goals and Sustainable Prosperity Act, of 9.7 megatonnes in 2010 which declines to 7.5 megatonnes in 2020;
- a target of meeting 25% of electricity needs from renewable sources by 2020;
- a commitment to increasing vehicle efficiency and developing a Sustainable Transportation Strategy by 2010;
- increasing overall provincial energy efficiency by 20% over current levels by 2020;
- requiring energy efficiency requirements in the building codes; and,
- support for the development of biomass/biofuels.

Nova Scotia is a signatory to the New England Governors/Eastern Canadian Premiers Climate Change Action Plan. This plan includes a commitment to reduce regional GHG emissions to 1990 levels by 2010, 10% below 1990 levels by 2020, and recognizes a long term need to require reductions of 75 – 80 %. The plan has identified energy demand, electricity, and transportation as key sectors for emissions reduction. Through the Conference of New England Governors and Eastern Canadian Premiers, the Atlantic Provinces are observing the workings of the Regional Greenhouse Gas Initiative cap-and-trade program and exploring similar opportunities.

Nova Scotia has signed on to the Atlantic Energy Framework for Collaboration. This is an agreement designed to increase cooperation on the energy development to produce a more sustainable, reliable, and secure energy supply. This cooperation will be required if the region is to more fully develop its renewable energy resources.

Nova Scotia is an Observer to the Regional Greenhouse Gas Initiative (RGGI), which is a cooperative effort by ten Northeast and Mid-Atlantic states to limit

greenhouse gas emissions. RGGI is the first mandatory, market-based $CO_2$ emissions reduction program in the United States.

## 4.6.8 Nunavut

At the January 28, 2008, Council of the Federation meeting on climate change adaptation, the northern Premiers agreed to develop a Northern Adaptation Strategy which will explore issues such as effects of permafrost melting, infrastructure degradation, challenges to wildlife, invasive species and plant life, and the opportunity and challenges associated with the opening of the Northwest Passage. The Nunavut government has also produced "Inuit Qaujimajatuqangit of Climate Change in Nunavut,"a territory wide examination of Inuit traditional knowledge with respect to climate change.

Nunavut released an energy strategy in 2006. One of its major goals is to reduce dependency on imported fuel through conservation and development of renewable energy sources. Virtually all fuel used for heating and electricity is imported and the territory spends about 20% of its budget on purchasing, selling and subsidizing fuel.

## 4.6.9 Ontario

### Climate Change Action Plan (CCAP)

Since 2007, Ontario has announced key initiatives, passed legislation, and made strategic investments to support the CCAP. Ontario has enhanced its internal capacity to monitor, validate and report progress towards its CCAP targets, which is reflected in an annual report to the public. Ontario has also entered agreements to participate with various other jurisdictions on climate change activities. Some of the key initiatives are summarized below.

### Green Energy, Conservation and Efficiency

Ontario's Green Energy Act received Royal Assent on May 14, 2009. The intent of the Green Energy Act is to make it easier to implement renewable energy projects, and to foster a culture of conservation by assisting homeowners, government, schools and industry to transition to lower and more efficient energy use. It is anticipated that the Green Energy Act will create 50,000 new jobs in the green energy sector. Key elements of the act include:

- A Feed-In-Tariff (FIT) program, which allows individuals and companies to sell renewable energy – like solar, wind, water, biomass, biogas and landfill gas - into the grid at set rates.
- A streamlined approvals process and a service guarantee to bring developers greater certainty.

The Green Energy Act supports Ontario's phase out of coal-fired electricity generation by the end of 2014; this is expected to reduce Ontario's annual carbon dioxide emissions by up to 30 megatonnes.

Ontario's Home Energy Savings Program provides grants for home energy audits and energy efficiency improvements.

Investments in smart grid technology and research will facilitate the integration of renewable energy.

Ontario has installed more than 3 million smart meters to date with a goal of 4.5 million, helping to empower Ontarians to make more informed decisions about their electricity consumption.

The Ontario Building Code is updated every 5 years. The next revisions in 2011 and 2016 will include increased energy efficiency standards.

In addition, Ontario has established the Ontario Public Service Green Transformation Strategy to reduce emissions from government operations.

### Cap and Trade, and Reporting

Ontario is working with other jurisdiction to support the development of regional based cap and trade systems including:

- Ontario signed a Memorandum of Understanding with Quebec in June 2008.
- Ontario became a member of the Western Climate Initiative in 2007.
- Ontario is an observer of the Midwestern Greenhouse Gas Reduction Accord and the Regional Greenhouse Gas Initiative.
- In 2009 Ontario joined the International Carbon Action Partnership.

Ontario released two discussion papers on cap and trade and also hosted a benchmarking workshop with Quebec that brought industry and government experts from the European Union, United States and Canada to share experiences, information and best practices regarding cap and trade allocations through benchmarking.

In December 2009, Bill 185, the Environmental Protection Amendment Act (Greenhouse Gas Emissions Trading), 2009 received Royal Assent and provides a foundation for Ontario to introduce regulations to implement a GHG cap-and-trade program that can link to other emissions trading systems.

Ontario's GHG Reporting Regulation (O.Reg 452/09) under the Environmental Protection Act provides an important tool to support the implementation of a cap-and-trade program.

In 2008 Ontario joined The Climate Registry, a multi-state, tribe, and provincial collaboration to develop a common reporting system.

#### Transportation

The MoveOntario 2020 initiative provides for $11.5B in public transit projects in the Greater Toronto Area and Hamilton.

Greening government fleets and public transit fleets - 20% of eligible new public sector vehicles will be electric.

Ontario's electric vehicle strategy will provide for incentives for plug-in hybrid vehicle including rebates of $4,000-$10,000, with a goal of 1 in 20 vehicles driven in Ontario to be electric by 2020.

In 2007, Ontario and California signed a Memorandum of Understanding agreeing to cooperate on low carbon fuel standards, energy efficiency programs, clean energy and emissions trading.

#### Green Jobs and Research

Ontario has a number of initiatives in place to support green jobs in the near and long-term. The Green Energy Act, the Next Generation of Jobs Fund as well as the Ontario Emerging Technologies Fund are designed with green job creation as a priority.

Ontario's $3.2B Innovation Agenda also includes key investments in research, development and commercialization in innovative industries, including an emphasis on new clean energy technologies and building the next-generation of "green"cars.

#### Land Use and Stewardship

Places to Grow Act and the proposed Far North Act, set out frameworks for sustainable growth that protect the provinces natural resources and recognize the carbon storage and sequestration capacity of natural areas.

The Far North Act would protect at least 225,000 square kilometres of the Northern Boreal Region.

50 Million Tree Program, will see 50 million new trees in Southern Ontario by 2020.

Urban Greening Initiative resulted in 100,000 trees planted in urban areas in 2008-2009.

The Community Go Green Fund provides funding to community-based grassroots projects to fight climate change.

Ontario passed regulations requiring landfill gas collection at landfills greater than 1.5 million cubic meters.

### 4.6.10 Prince Edward Island

Specific programs within the strategy include:

- the development of building codes and energy standards;
- plans to generate 500 MW of wind energy by 2013 (they had a goal of 15% of electricity generation from renewable energy by 2010 and achieved this in 2007);
- consideration of biomass/biofuel potential; and,
- support for low emission vehicles and California vehicle emissions proposals.

Prince Edward Island is a signatory to the New England Governors/Eastern Canadian Premiers Climate Change Action Plan. This plan includes a commitment to reduce regional GHG emissions to 1990 levels by 2010, 10% below 1990 levels by 2020, and recognizes a long term need to require reductions of 75 – 80 %. The plan has identified energy demand, electricity, and transportation as key sectors for emissions reduction. Through the Conference of New England Governors and Eastern Canadian Premiers, the Atlantic Provinces are observing the workings of the Regional Greenhouse Gas Initiative cap-and-trade program and exploring similar opportunities.

Prince Edward Island has signed the Atlantic Energy Framework for Collaboration. This is an agreement designed to increase cooperation on the energy development to produce a more sustainable, reliable, and secure energy supply. This cooperation will be required if the region is to more fully develop its renewable energy resources.

Prince Edward Island is an Observer to the Regional Greenhouse Gas Initiative (RGGI), which is a cooperative effort by ten Northeast and Mid-Atlantic states to limit greenhouse gas emissions. RGGI is the first mandatory, market-based $CO_2$ emissions reduction program in the United States.

### 4.6.11 Quebec

Quebec's approach to addressing climate change is based mainly on four major and complementary policies, namely: an energy strategy, a climate change action plan, a public transit strategy, and a development strategy for Quebec's environmental and green technology industry.

### Energy Strategy 2006-2015 (May 2006):

This strategy, based on the development of renewable energy (hydroelectricity, wind and biomass), targets a more efficient use of all forms of energy. One of the objectives is to achieve energy savings of 2 million tonnes of oil equivalent (TOE) by 2015, which is a first in this sector.

- Capacity for 4,000 MW of new wind energy projects within 5 years.
- Added capacity of 4000 MW of hydroelectricity by 2015.
- Energy efficiency target of 11 TWh by 2015

### 2006-2012 Climate Change Action Plan

The plan's $1.55 billion budget will be used towards the implementation of 26 measures related to the reduction of greenhouse gas (GHG) emissions, and climate change impacts and adaptation. A duty on gasoline and fossil fuels, on the order of $200 million per year, will ensure the majority of the funding for these measures. The measures target the following sectors: energy, transport, municipalities, the industrial sector, residual materials, agriculture, health, public security, the environment, natural resources and provincial lands. The target of the plan is to reduce GHG emissions by 6% below the 1990 levels by the year 2012.

In 2006, the government relied on voluntary measures from the industrial sector. However, in the spring of 2008, the government joined with the Western Climate Initiative to ensure the establishment of a regional emissions exchange system based on absolute GHG emission reductions starting in 2010 starting with mandatory GHG emission reporting from large emitters. An act enabling the adoption of regulations for this purpose was passed in June 2009.

Among the action plan's key measures:

- Energy efficiency program ($185 million) including a plan to reduce the use of heavy fuel oil (Plan Mazout), a support for the manufacturing sector program, a refrigeration optimization program, and a forest biomass heating assistance program.
- Various measures supporting the research, development and demonstration of technologies to reduce GHG emissions. For example, the Technoclimat program finances projects that demonstrate innovative technologies and processes that have strong potential for reducing greenhouse gas emissions in Quebec.
- Regulation on GHG emissions for light-duty vehicles equivalent to the Californian standard. The regulation is operational and covers 2010 model year and following model years up to 2016.
- Regulations making the use of speed limiters mandatory for all trucks, prohibiting idling, and strengthening emission standards for diesel trucks
- Programs for using biomethane by processing residual biomass and reducing biogas from landfills.
- Programs to improve energy efficiency and intermodality in the transport of merchandise.

### Quebec Public Transit Policy (June 2006)

To reduce emissions from this sector, the government is focusing on public transit and intends to achieve an 8% increase in ridership within 5 years. More than $4.5 billion will be granted to this sector to finance the renovation of existing infrastructures and to increase the service offer. The policy consists of seven assistance programs for passenger transportation.

### Development Strategy for Quebec's Environmental and Green Technology Industry (May 2008)

The purpose of the strategy is to combine economic development with the achievement of environmental objectives, such as reducing GHGs in Quebec, and to make the industry a leader in innovation.

### Quebec's International Partnerships

The Government of Quebec has been actively involved in developing climate change partnerships in North America and abroad. Over the past four years, it has joined the efforts of the following organizations:

- The Climate Group (2006), an international organization dedicated to promoting best practices in GHG emissions and the rapid development of new green technologies such as electric vehicles and LED lighting.
- The Climate Registry (April 2007), a collaborative registry among several North American states which has become one of the Western Climate Initiative's (WCI) main partners.
- The Western Climate Initiative (April 2008), a coalition of North American provinces and states supporting the establishment of a common market for the exchange of GHG emission credits.

- The International Carbon Action Partnership (ICAP), a coalition of North American and European states that promotes the global carbon marketplace as a tool in the fight against climate change.
- The Territorial Approach to Climate Change, a UNDP program aimed at creating partnerships between subnational governments from the North and South.
- EV20: an international initiative convened by The Climate Group aimed at facilitating the deployment of electric vehicles.

### 4.6.12 Saskatchewan

The Management and Reduction of Greenhouse Gases Act announced on December 1, 2009 provides for:

- Creation of an Office of Climate Change in the Ministry of Environment;
- Regulation of major greenhouse gas emitters;
- Provincial carbon price for regulated emitters;
- Saskatchewan Technology Fund to collect carbon compliance payments from large emitters to invest in low-emitting technologies to reduce greenhouse gas emissions;
- A Climate Change Foundation to promote research and development of low carbon technologies, adaptation and public education and awareness; and,
- Performance agreements with large emitters to reduce greenhouse gas emissions outside of regulated activities and with non-regulated emitters in the agriculture, transportation, commercial and residential building sectors.

The Go Green Fund provided financial support for the following initiatives in 2009:

- 20% rebate on insurance and registration fees for hybrid and fuel-efficient vehicles;
- Incentives for homeowners to install geothermal, solar and wind generation, which includes a new loan program for people who install one of these systems;
- Rebates of 35%, to a maximum of $35,000 to customers who wish to self-generate electricity using green sources such as wind or solar and participate in the Net Metering Program; and,
- Support for clean energy technologies and energy efficiency research, demonstration and development projects.

SaskPower Eneraction programs involve planning, implementing, and monitoring activities designed to encourage customers to reduce power consumption by:

- A campaign to promote ENERGY STAR® appliances with a PST exemption;
- Helping large commercial and institutional customers retrofit their buildings to become more energy efficient;
- Offering industrial energy audits to help larger customers reduce energy use;
- Using education and financial incentives to improve the efficiency of commercial and municipal lighting; and,
- Improving efficiencies within SaskPower's transmission and generation system.

#### Wind Power and Renewable Energy Sources

The 2009 Saskatchewan Throne Speech announced that the contribution of wind energy to meeting provincial electricity supply requirements would be increased in 2010.

The Green Options Plan and the Green Options Partners Program were announced by SaskPower on October 28, 2009, to expand existing provincial wind energy capacity, and promote other renewable energy technologies.

Under the Green Options Partners Program, up to 175 MW of wind power will be procured by SaskPower from one of more independent power producers. This will double existing provincial wind energy capacity of 172 MW. Other renewable energy sources such as solar, biomass, hydro, waste heat recovery, and flare gas will also be developed under the program.

Planned expansion of wind energy capacity and renewable energy sources is estimated to reduce SaskPower's GHG emissions by about 225,000 tonnes annually.

#### Saskatchewan is currently engaged in a number of Carbon Capture and Storage (CCS) Initiatives including:

- Formation of the International Performance Assessment Centre for Geologic Storage of $CO_2$ (IPAC-$CO_2$) at the University of Regina in partnership with the Government of Saskatchewan,

Shell Canada and the University to create a global network of advice and experience on carbon capture and storage best practices.

- $240 million in federal funding for a SaskPower demonstration project to capture 1 million tonnes a year of $CO_2$. Projected emissions reductions are estimated at 7.2% from 2006 levels. This seven-year, $1.4 billion government-industry partnership rebuilds a major coal – fired power generation unit at Boundary Dam.

- Provincial announcement on May 7, 2009 to develop a large international carbon capture and storage project with Montana to achieve:

- Construction of a technology-neutral $CO_2$ capture plant at an existing coal-fired electrical generating station in Saskatchewan with the flexibility to employ a range of post-combustion carbon capture technologies and capture a million tonnes of $CO_2$ over a four year period;

- Construction of a North American $CO_2$ storage facility in eastern Montana including injection infrastructure with options of using $CO_2$ for enhanced oil recovery;

- Construction of pipeline infrastructure for transportation of $CO_2$ from the reference plant in Saskatchewan to storage facility in Montana; and

- Development of a North American training facility to meet the needs of a growing carbon capture and storage industry and regulators, based primarily at the University of Regina and Montana State University.

- The Aquistore project is a collaborative CCS initiative between government, industry and research institutions to demonstrate that storage of greenhouse gas emissions in deep geologic formations is a safe effective solution for greenhouse gas reduction. The project is managed by the Petroleum Research Technology Centre and is expected to store 500,000 tonnes of $CO_2$ by 2013.

Support for biofuels requiring all Saskatchewan fuel distributors to distribute an average blend of 7.5% ethanol in unleaded gasoline. The province is working with industry to develop E-85 (fuel blends of 85 per cent ethanol and 15 per cent gasoline) corridors.

Ethanol catalyst development to use agricultural and forestry residues to produce ethanol from biomass through fermentation and thermochemical processes in partnership with government, the Nipawin Ethanol Co-operative Ltd., and the Saskatchewan Research Council.

Crown Investments Corporation is coordinating initiatives by Saskatchewan Crown corporations to measure, report, and verify GHG emission data through The North American Climate Registry.

A Memorandum of Understanding between the State of Victoria, Australia, and the Saskatchewan government was signed at COP15 in Copenhagen, to pursue research and demonstration of low-carbon technologies, renewable energy sources, and adaptation planning initiatives.

## 4.6.13 Yukon

The Yukon Government Climate Change Action Plan was released in February 2009. The Action Plan recognizes many actions already underway and sets out 33 new or enhanced actions the Yukon govemment will undertake in support of enhancing knowledge and understanding of climate change, adapting to climate change, reducing greenhouse gas emissions and leading Yukon action in response to climate change. A key initiative was the creation of the Climate Change Secretariat. The Secretariat provides corporate leadership on climate change within Yukon government. The Action Plan commits to setting Yukon wide emission targets for 2011.

Yukon Government released its Energy Strategy on January 23, 2009. The Strategy considers how to best meet Yukon's energy needs while balancing environmental and economic objectives for the Territory. Key initiatives related to Climate Change include:

- increasing total renewable energy generation in the territory by 20% by the year 2020;

- increasing territorial energy efficiency by 20% by the year 2020;

- exploring the possibilities of a Yukon carbon market; and

- developing/implementing industry best management practices for GHG emissions.

The strategy identifies energy priorities and proposes both a vision for the energy sector and principals to guide Yukon government decision-making as it relates to energy. The Strategy proposes goals, long-term strategies and short-term actions for electricity, renewable energy, energy efficiency/conservation and oil and gas.

## 4.7 Description of Steps Taken to Promote or Implement ICAO or IMO Decisions to Reduce or Limit GHG Emissions

### Air

The Government continues to support harmonized international efforts to limit or reduce both domestic and international aviation emissions of both greenhouse gases and air pollutants. The Minister of Transport supports the work of the International Civil Aviation Organization to develop international standards and recommended practices for the reduction of greenhouse gas and air pollutant emissions from aviation sources. These standards and recommended practices will be considered in the development of domestic regulations under the Aeronautics Act.

In support of domestic regulations, Canada has played a leadership role in encouraging advancement of concrete plans, goals and approaches to achieve emissions reductions for aviation. In 2005, Canada negotiated with its domestic air carriers the first voluntary Memorandum of Understanding (MOU) of its kind in the world to reduce emissions; the MOU commits to achieve a 24% cumulative improvement in fuel efficiency between 1990 and 2012.

In addition, the International Civil Aviation Organization's Committee on Aviation Environmental Protection, in which Canada actively participates, has developed extensive guidance on the use of operational measures. One document, Circular 303 identifies and reviews various operational opportunities and techniques for minimizing fuel consumption and hence $CO_2$ emissions, in civil aviation operations. Operations covered in the guidance are: ground level and in-flight aircraft operations, ground service equipment (GSE) and auxiliary power units (APUs) with potential actions to facilitate their broader application. This document is being revised and expanded into a new ICAO Guidance Manual to further the implementation of operational measures on a global basis.

With respect to monitoring and reporting, Transport Canada, in collaboration with the Canadian Airports Council (CAC), has developed a Greenhouse Gas inventory tool for Canadian airports. The tool is being used as part of the initial phase of a program of action to reduce GHG emissions at Canadian airports. Recommendations on measures for emissions reductions will be linked with the International Civil Aviation Organization's work on emissions reductions from operations and with domestic and international aviation environmental research including: the Canadian Aerospace Environmental Technology Road Map (CAETRM), the Green Aviation Research and Development Network (GARDN), the Aircraft Emissions Environmental Measurements (AEEM) Program and the Partnership for Air Transport Noise and Emissions Reduction (US FAA, NASA, and Transport Canada funded center of excellence).

### Marine

Canada is working with other countries at the International Maritime Organization to address the impacts of the international shipping sector on climate change. The Government of Canada supports the development of a stringent global greenhouse gas emissions regime that applies equally to ships of all flags, as this would reduce the likelihood of unilateral and regional actions to reduce emissions from ships and provide a uniform global policy environment for the shipping industry. Once adopted, these international standards would be implemented domestically by regulations under the Canada Shipping Act, 2001.

## 4.8 How the Design and Implementation Policies and Measures Minimizes Adverse Economic, Environmental and Social Impacts on Lesser-Developed Countries, Small Island States and Fossil Fuel Dependent Economies

Canada's processes to establish and implement climate change response measures include consultations with Federal Departments with international responsibilities, including the Department of Foreign Affairs and International Trade and the Canadian International Development Agency (CIDA). These Departments provide advice on international aspects of proposed measures. Canada also consults with provincial and provides for extensive public consultation processes, during which domestic and foreign stakeholders can raise concerns and issues about the proposed measures.

The Government's regular trade, economic and political consultations with other governments also provide opportunities to raise and address concerns about the possible impacts of Canada measures. Similarly, regular Official Development Assistance discussions give partner country governments the opportunity to raise concerns about adverse impacts.

Canada maintains an open trading environment, consistent with the principles of free trade and investment, ensuring that both developed and developing countries can maximise opportunities in Canada's market regardless of the climate change response measures Canada undertakes. Canada also works with partner developing countries to strengthen their governance and enabling environments, improving their ability to respond to changing circumstances.

Canada also uses Strategic Environmental Assessments (SEA) to encourage government departments and agencies to incorporate environmental considerations into the review process of policies, plans and programs that, if approved, would lead to the development of public policy. SEAs consider a number of factors:

- The scope and nature of the likely environmental effects
- The need for mitigation to reduce or eliminate adverse effects
- The likely impact of any adverse environmental effects

SEAs consider, in equal measure, both economic and social analyses. The depth and scope of the assessment is also commensurate with the possible environmental impact of the proposal.

## 4.9 References

Notice of intent to develop and implement regulations and other measures to reduce air emissions
http://canadagazette.gc.ca/archives/p1/2006/2006-10-21/html/notice-avis-eng.html#i3

Canada's New Government Announces Mandatory Industrial Targets to Tackle Climate Change and Reduce Air Pollution
http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=4F2292E9-3EFF-48D3-A7E4-CEFA05D70C21

Government's new biofuels plan a double win: Good for the environment and farmers
http://www.ecoaction.gc.ca/news-nouvelles/20070705-2-eng.cfm

ecoENERGY for Biofuels Initiative
http://oee.nrcan.gc.ca/transportation/ecoenergy-biofuels/index.cfm?attr=16

Government of Canada Calls on Industry to Participate in New Biofuels Initiative
http://www.ecoaction.gc.ca/news-nouvelles/20071203-eng.cfm

Government of Canada Gets Tough on Climate Change: Orders Industry to Submit Air Emissions Information
http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=0F208D84-395E-4E78-8E6F-CCB906C30F5B

Privy Council Office
http://www.pco-bcp.gc.ca/index.asp?lang=eng&page=information&sub=publications&doc=Decision/canada-eng.htm

Canadian Environmental Sustainability Indicators (CESI)
http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En

Turning the Corner: Regulatory Framework for Industrial Greenhouse Gas Emissions
http://www.ec.gc.ca/doc/virage-corner/2008-03/541_eng.htm#targets

Sustainable Development Strategy 2007-2009
http://www.ec.gc.ca/sd-dd_consult/SDS2007/toc_e.htm

Implementation Progress Report April 2007-March 2008
http://www.ec.gc.ca/sd-dd_consult/DPR2007Table_e.html

Canadian Council of Ministers of the Environment (CCME)
http://www.ccme.ca/about/

A Climate Change Plan for the Purposes of the Kyoto Protocol Implementation Act - 2009
http://www.ec.gc.ca/doc/ed-es/KPIA2009/tdm-toc_eng.htm

Budget 2007
http://www.budget.gc.ca/2007/plan/bpc3-eng.html

Budget 2008
http://www.budget.gc.ca/2008/home-accueil-eng.asp

Turning the Corner
http://www.ec.gc.ca/cleanair-airpur/Turning_the_Corner-WSF3084CB7-1_En.htm

Credit for Early Action
http://www.ec.gc.ca/cmap-cea/default.asp?lang=En

Budget 2009
http://www.budget.gc.ca/2009/home-accueil-eng.asp

EcoAction Community Funding Program
http://www.ec.gc.ca/ecoaction

Retire Your Ride Program
http://www.retireyourride.ca/retire-now.aspx

Moving On Sustainable Transportation (MOST)
http://www.tc.gc.ca/programs/environment/MOST/menu.htm

National Vehicle Scrappage Program
http://www.ec.gc.ca/cleanair-airpur/Sustainable_Transportation/Vehicle_Scrappage_Program-WSF8711200-1_En.htm

Canada's Offsets System for Greenhouse Gases
http://www.ec.gc.ca/creditscompensatoires-offsets/default.asp?lang=En&n=109DDFBA-1

Québec and Climate change, A Challenge for the Future – 2010-2010 Action Plan
http://www.mddep.gouv.qc.ca/changements/plan_action/index-en.htm

# Chapter 5

# Emissions Projections

## 5.1 Overview

On June 22, 2007, the Kyoto Protocol Implementation Act (KPIA) received Royal Assent. Section 5 of the KPIA requires the Minister of the Environment to prepare a plan annually until 2013 with: a) a description of measures; b) the GHG emission reductions expected from each measure to 2012; and c) the projected overall GHG emission levels for each year from 2008 to 2012 based on those measures.

The 2009 KPIA Plan – A Climate Change Plan For The Purposes of the Kyoto Protocol Implementation Act – includes projected emission reductions for each of the policies and measures described in Chapter 4 of this communication individually and in aggregate. The KPIA Plan also provides a reference case for "business as usual" projections, as well as a summary of the methodology used to prepare the projections.

The 2009 KPIA Plan is available at http://www.ec.gc.ca/doc/ed-es/KPIA2009/tdm-toc_eng.htm

In addition to the policies and measures described in Chapter 4 of this national communication, the 2009 KPIA Plan also describes the "Regulatory Framework for Industrial Greenhouse Gas Emissions" as outlined in the Government's Turning the Corner Plan. In 2009, the Government indicated that it was refining that regulatory approach to reflect the new realities of the global economic downturn and the opportunities represented by the new Administration in the US. Consistent with the focus of this communication on policies and measures implemented or announced and funded prior to April 2009, Chapter 4 does not include a description of that regulatory framework.

Consistent with the legal requirements of the KPIA, the Government intends to table its Climate Change Plan for the Purposes of the Kyoto Protocol Implementation Act 2010 not later than May 31, 2010. The 2010 Plan will outline the existing domestic actions that the Government of Canada is taking to reduce its greenhouse gas emissions. This plan will be made available to the UNFCCC Secretariat upon its public release.

## 5.2 The Reporting Requirements of the Kyoto Protocol Implementation Act

The 2009 KPIA Plan describes the relevant legal requirements as follows:

*"As per the Kyoto Protocol Implementation Act, this Plan fulfills the following legal requirements:*

*Section 5 of the Act provides that Within 60 days after this Act comes into force and not later than May 31 of every year thereafter until 2013, the Minister [of the Environment] shall prepare a Climate Change Plan that includes:*

(a) *a description of the measures to be taken to ensure that Canada meets its obligations under Article 3, paragraph 1, of the Kyoto Protocol, including measures respecting:*

  (i) *regulated emission limits and performance standards,*

  (ii) *market-based mechanisms such as emissions trading or offsets,*

  (iii) *spending or fiscal measures or incentives,*

  (iii)(1) *a just transition for workers affected by greenhouse gas emission reductions,*

  *and*

  (iv) *cooperative measures or agreements with provinces, territories or other governments.*

(b) *for each measure referred to in paragraph (a),*

  (i) *the date on which it will come into effect, and*

  (ii) *the amount of greenhouse gas emission reductions that have resulted or are expected to result for each year up to and including 2012, compared to the levels in the most recently available emission inventory for Canada;*

(c) *the projected greenhouse gas emission levels in Canada for each year from 2008 to 2012, taking into account the measures referred to in paragraph (a), and a comparison of those levels with Canada's obligations under Article 3, paragraph 1, of the Kyoto Protocol;*

(d) *an equitable distribution of greenhouse gas emission reduction levels among the sectors of the economy that contribute to greenhouse gas emissions.*

*Two additional requirements under section 5 of the Act are addressed in the 2009 Plan. Paragraphs (e) and (f) of section 5 (1) stipulate that the Government must publish:*

(e) *a report describing the implementation of the Climate Change Plan for the previous calendar year; and*

(f) *a statement indicating whether each measure proposed in the Climate Change Plan for the previous calendar year has been implemented by the date projected in the Plan and, if not, an explanation of the reason why the measure was not implemented and how that failure has been or will be redressed.*

*Section 9 requires that the Minister of the Environment prepare, within 120 days after the Act comes into force, a statement setting out the greenhouse gas emission reductions that are reasonably expected to result for each year up to and including 2012 from each regulation and measure. No similar requirement exists for any of the Plans following the 2007 Plan. To review the Statement, please see the 2007 Climate Change Plan."*

## 5.3 Estimated Annual Emissions and Emission Reductions

In accordance with the obligations under Section 5 of the KPIA, the 2009 KPIA Plan includes a detailed chapter describing individual policies and measures together with the projected impact each policy and measure will have on emissions for each year in the 2008 to 2012 period. The introduction to that chapter emphasizes that: "The Government's domestic climate change agenda will continue to evolve over time." It further observes that:

*"While the Plan provides contextual information on new climate change measures, emissions reductions estimates are only provided for those measures that are expected to result in emissions reductions during the Kyoto period, as per the requirements of the Kyoto Protocol Implementation Act."*

In addition to the estimated impact of each policy and measure, the 2009 KPIA Plan provides the projected impact of all of the policies and measures in aggregate. The description of the aggregate emissions is as follows:

*"Under the reference case, and excluding the measures presented in this Plan, Canada's baseline emissions levels are expected to increase from 749 Mt in 2008 to 790 Mt in 2012. Under the reference case, the economy is projected to grow at 2.2% per year over the 2008 to 2012 period. Over the same period, the world oil prices are assumed to average about $75 per barrel (in US$2008).*

*With the measures presented in this Plan – including both federal measures and provincial/territorial measures – emissions levels are expected to be about 1 Mt below the baseline at 748 Mt in 2008 and about 74 Mt below the baseline at 716 Mt in 2012. Given the reductions anticipated from the measures in this Plan, Canada expects to be 802 Mt above its Kyoto Protocol target of 2,792 Mt during the 2008 to 2012 period."*

## 5.4 Methodology

The 2009 KPIA Plan includes a detailed technical annex describing the approaches used to calculate estimated reductions from the policies and measures detailed in the report.

The introduction to the Annex explains that two types of estimation procedures were used:

*"Reduction estimates have been calculated on a case-by-case basis for the individual measures in the document as per paragraphs 5 (1) b (ii) of the Act. In addition, Environment Canada's integrated Energy, Emissions and Economy Model for Canada (E3MC) was used to estimate the emissions reduction for the overall integrated package of measures and the modeled results were used to report on Canada's emission reductions and total remaining emission levels for 2008-2012, thereby satisfying paragraph section 5(1)(c) of the Act.*

*The advice of the National Round Table on the Environment and the Economy is a key factor in the Governments' methods for estimating reductions. The Response of the National Round Table on the Environment and the Economy to its Obligations Under the Kyoto Protocol Implementation Act (September 2007) suggested certain methodological improvements for the development and presentation of reasonably expected emission reductions. These included the following:*

- *Transparency and clarity regarding assumptions and methodologies;*
- *Consistency in accounting for emission reductions over the relevant time period; and,*
- *Integrative accounting of results, where all programs are assessed in an integrated manner and the overall contribution accounts for positive and negative interactions between measures and regulations."*

The 2009 KPIA Plan further provides the following description of the approach taken to produce the estimates of a reference case of aggregate emissions and

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| | | | Mt | | |
| Projected emissions excluding Government Measures | 749 | 739 | 743 | 766 | 790 |
| Expected emissions including Government Measures | 748 | 737 | 691 | 702 | 716 |
| Expected emissions reductions | 1 | 2 | 52 | 64 | 74 |

Table 5.1: Canada's Emission Levels
Source: A Climate Change Plan for the Purposes of the Kyoto Protocol Implementation Act (2009)

of the projected impact on emissions of the measures described in the report in aggregate as well as considerations relevant to assessing the estimates:

*"In accordance with paragraph 5 (1) (c), the text and the table (Table 5.1) set out Canada's projected greenhouse gas emission levels for 2008 to 2012 and how these levels compare with Canada's obligations under Article 3, paragraph 1, of the Kyoto Protocol. In addition to the levels in Table 5.1, provincial plans and actions are expected to lower Canada's emission levels over the period of 2008 to 2012. However, it is premature to estimate the resulting emissions reductions in the context of this Plan. The projected emission levels will be verified by the national inventory reports, the first of which will be due on April 15, 2010, with the final report for 2012 due on April 15, 2014. The degree to which Canada has met its emissions reduction obligations under the Kyoto Protocol will be assessed after its final report has been filed in 2014.*

*Canada's allowable emissions under the Kyoto Protocol for the period 2008 to 2012 are 2,792 Mt.*

*The Government of Canada used Environment Canada's integrated Energy, Emissions and Economy Model for Canada (E3MC) to estimate the reduction for the overall integrated package of measures.*

*The modeled runs incorporated the individual initiatives and aggregated the results to estimate Canada's net emission reductions from a continuing trends baseline to report the remaining emission levels for 2008-2012. This baseline already incorporates many measures and trends currently underway across Canada. Some of the measures included in the baseline are complementary to federal policies presented in this report. The date of January 1, 2006 was used as the cut-off point for defining existing measures that are to be included in the energy and emissions baseline projections. As such, to avoid double-counting, the impacts from these measures are not included in the total emissions reductions. The use of the model responds to the National Round Table's suggested methodological improvement for an "integrative accounting of the emission reduction estimates".*

*There are a number of key determinants that influence energy supply and demand, and emissions.*

*These determinants include:*

- *the pace of economic growth;*
- *population and household formation;*
- *energy prices (e.g., world oil price and price of refined petroleum products, regional natural prices, and electricity prices);*
- *technological change and policy decisions.*

*Varying any one of these assumptions could have a material impact on the energy and emissions outlook."*

## 5.5 Continuous Cycle of Improvement

The 2009 KPIA Plan also describes the continuous cycle of improvement applied to each annual plan under the KPIA:

*"Section 10 of the Kyoto Protocol Implementation Act requires the National Round Table on the Environment and the Economy (NRTEE) to review each annual Climate Change Plan within 60 days after it is published. Additionally, the Commissioner of the Environment and Sustainable Development (CESD) is required to prepare a report on the Plans at least once every two years.*

*At present, the NRTEE has provided reviews of the 2007 and 2008 Plans and the CESD's first review was recently completed. While the Government has not agreed with all of the recommendations made in these reviews, it has adapted each Climate Change Plan and improved reporting based on a number of the recommendations.*

*In the first KPIA Plan in 2007, the Government provided individual emissions reductions for each measure as required by the Act. In its first review, the NRTEE recommended that the Government also report on the measures in an integrated fashion to account for any*

*interaction effects between programs that could result in an overstatement of reductions. The Government responded to this recommendation in the 2008 Plan by providing an integrated reporting of measures using a modeling approach, as well as reporting the expected reductions for each measure consistent with the requirements of the Act. As a result, the Plan's overall integrated estimate will be different from the aggregate of the individual measures because it accounts for interaction effects. NRTEE welcomed this methodological change by noting that the 2008 Plan was a "significant improvement" from the 2007 Plan.*

*The cycle of improvement continues in the 2009 Plan with the inclusion of further refinements as suggested by the CESD. For example, greater detail is provided on the implementation status of the measures to which emission reductions are attributed during the Kyoto Protocol period. The Plan also provides greater detail in support of the Government's positions on two of the Act's requirements – provisions for a just transition for workers affected by measures in the Plan, and efforts to ensure an equitable distribution of emission reductions across sectors of the economy. Finally, the 2009 Plan provides uncertainty analysis for the reduction numbers for most of the measures, including a range of emissions reductions outcomes."*

# Chapter 6

# Vulnerability Assessment, Climate Change Impacts and Adaptation Measures

## 6.1 Introduction

Canada continues to expand the scientific understanding of the impacts of climate change, and in particular the vulnerability of different regions and sector. Canada has taken significant actions to prepare to adapt since Canada's Fourth National Communication on Climate Change in 2006. Canada's investments in climate change research in accordance with its commitments under the United Nations Framework Convention on Climate Change (UNFCCC) have now yielded a verifiable knowledge base, providing the necessary foundation for governments and organizations at all levels to act strategically and develop adaptation policies to protect the country's diverse natural resources, ecosystems and communities.

Current climate change impacts and projections are significant and broadly based across Canada and sectors. There have been key developments in our understanding of impacts in Canada. Climate change scenarios project an increased risk of extreme weather and other climate-related events in Canada such as floods, drought, forest fires and heat waves. Air quality in many Canadian communities is likely to be affected by climate change through increased smog formation, wildfires, pollen production, and greater emissions of air contaminants due to shifting human behaviours. These are all increasing risks to the health of Canadians. Across the country, climate change is also likely to increase risks associated with some infectious diseases and may result in the emergence of diseases that are currently thought to be rare in or exotic to Canada. Climate change is also affecting biodiversity and ecosystem health, including impacts on species distribution, timing of life cycles, rates of photosynthesis and changes in the make up of ecological communities, which, in turn, will impact natural resource sectors and the provision of ecosystem services such as pollination and flood regulation. Further, as a maritime nation with 8 out of 10 provinces bordering on the ocean as well as its 3 territories, Canada recognizes the significant impact climate change is having on our oceans and its resources.

The impacts are particularly apparent in Canada's Arctic North, where pronounced temperature increases are already having significant impacts on northern ecosystems and biodiversity, and the northern communities that rely on these resources. Some of these effects are already evident: access to traditional food supplies has been affected by changes in snow cover and sea-ice conditions; there is evidence of shifts in availability, quality and accessibility of some species; and the melting permafrost and coastal erosion present challenges to community infrastructure. These all have large social, cultural and economic implications that are becoming better understood. Some northern systems and populations are particularly vulnerable, and their current ability to respond to climate change impacts is being challenged and eroded by the social, cultural, political and economic changes taking place in response to a range of stresses.

Climate change poses a serious threat to ecosystems. At the same time, protecting healthy ecosystems can provide natural buffers to the impacts of climate change, including extreme weather events while also providing other benefits such as protecting biodiversity, supporting tourism, and enhancing carbon stores. Known as ecosystem-based adaptation, this approach is recognized internationally as an important part of climate change adaptation. In line with this approach, Canada has increased its focus on the establishment and effective management of protected areas, particularly in northern Canada.

It is also important to note that Quebec is proactive despite uncertainties regarding the scope of climate changes that will affect its territory and has already begun adapting in order to minimize risks associated with these impacts (e.g. program to reduce heat islands in Quebec municipalities).

Climate change has now come to the forefront as a key concern in Canada, with action being taken at many levels including federal agencies, provincial agencies, municipal agencies, non-governmental organizations, professional associations, and regional centres of expertise. The Canadian government carried out

new climate change vulnerability assessments, including a national-scale assessment based on a regional analysis of present and future risks and opportunities that climate change presents to human and managed systems across Canada. Also, sectoral-specific analyses of vulnerability were conducted for human health and forestry. There are also major new research initiatives underway, including developing tools for facilitating adaptation science.

## 6.2 Expected Impacts of Climate Change on Canada

Significant progress has been made in Canadian scientific research and understanding of the continuing impacts of climate change since Canada's Fourth National Communication.

### 6.2.1 Agriculture

Canada has a long-standing and significant agricultural history and capacity. The agriculture sector is a vital component of the Canadian economy, currently accounting for approximately eight per cent of the Gross Domestic Product. In terms of global trade, Canada is the world's fourth biggest exporter and fifth biggest importer of agricultural and food products.

While Canada's land mass covers 9,093,507 square kilometres, the soil and climate conditions limit the amount of farmable land. Approximately seven per cent of the land (636,545 square kilometres) can be farmed with current technologies. Most of Canada's farmland is in the western region; 82 per cent of the country's agricultural land extends across the southern part of the three Prairie provinces. Primary agricultural production dominates this region and includes bulk grains and oilseeds such as wheat, barley, and canola; livestock such as cattle, pigs and horses; and hay production for animal feed.

The other significant agricultural region is in eastern Canada; it spans the southern parts of Ontario and Quebec, through to the Maritime provinces. Although there is substantially less agricultural land in the east, the region has a higher number of individual farm operations. The majority of these farms are engaged in "value-added" agri-food production such as the processing of milk from dairy cows into cheese and yogurt, and the processing of fruits and vegetables into canned and frozen foods, jams, juices and wines.

Canadian climate impact research identifies a variety of regional impacts and shifts in precipitation and temperature trends. Increasing periods of water scarcity represent the most serious risk. Canada's national drought in 2001/02 (which resulted in overall agricultural and economic losses estimated to be in excess of $5 billion) had impacts across all regions, from decreased crop production and more variable crop yield (Table 6.1) to disease and insect outbreaks. The impacts on crops and livestock are multifaceted. For example, warming temperatures may have the potential to shift agricultural zones further northward, although soils suitable for agricultural production may not be available in these regions. Conversely, there may be losses in productive land as southern extents likely become increasingly arid. Increasing climate variability may result in more of the annual precipitation arriving during the winter months and less during the summer growing season. And variability may also decrease the predictability of the frost free period. Livestock production costs are expected to rise with increasing energy demands for artificial cooling of livestock buildings. Warmer climatic conditions will also increase the occurrence of animal diseases and proliferation risks.

The impacts of climate change on both domestic food security, for both Canada and other countries, must be factored into future policies. Because it is generally able to maintain a high level of prosperity and food security domestically, Canada has the capability to help others around the world in their struggle to secure effective governance and improve their standard of living. To this end, Canada makes extensive contributions to help less well-off countries increase their food security through bilateral and multilateral efforts. Currently, Canada's Action Plan for International Food Security consists of seven commitments focused on these objectives: an enabling environment, access to food, sustainable agriculture and rural development, trade and food security, emergency prevention and preparedness, promoting investment and implementation and monitoring.

### 6.2.2 Biodiversity and Ecosystems

Canadian biodiversity and ecosystems have already been impacted by climate change in many ways. Longitudinal studies based on global satellite data have established that over the last two decades, forest and plant species across the Northern hemisphere's temperate zones have experienced earlier spring onsets by approximately 10 to 14 days. Canadian field studies confirm that many plant species are sprouting leaves and flowering earlier. For example, the spring onset of the trembling aspen in Canada's western region has advanced earlier by 2.6 days each decade since 1900.

The warming climate and related biodiversity and ecosystem impacts are especially acute in Canada's

| Region | Impacts |
|---|---|
| British Columbia | Vegetable crop losses<br>Damage to forage crops (especially in northern interior Okanagan region) |
| Prairies | Drop in wheat and canola production (43 per cent in 2000)<br>Decreased grain production (estimated losses of $5 billion)<br>Unprecedented spring irrigation water rations (Alberta)<br>Increased problems with canola, barley and wheat crop (Manitoba) |
| Great Lakes-St. Lawrence | Crop losses due to dry weather and high heat conditions (Ontario)<br>Increased crop stresses (disease, insects and hail)<br>Record numbers of some insect species (Quebec) |
| Atlantic | Reduced potato harvest (down by 35% to 45% on Prince Edward Island)<br>Drought stress on fruit, berry and vegetable crops |

Table 6.1: Impacts of the 2001/02 Canadian drought on agricultural crops

North. Many northern Aboriginal communities are already experiencing constraints on their traditional economic and activities ways of life. Sea and lake ice are less and less reliable, affecting the ability to travel, hunt, fish and whale. Climate-related wildfires and insect outbreaks have resulted in significant losses of forest resources, and damage to the caribou habitat.

Phenological research findings show that the increasing temperatures and climate variations are affecting wildlife dynamics, territorial range and migration, reproduction and dormancy patterns. Red squirrels in northern Canada now start breeding 18 days earlier than a decade ago. Red foxes have steadily roved well beyond their normal terrain into northern Canada, forcing the retreat of the smaller arctic foxes that are native to the Arctic tundra.

Studies in the Pacific Region have demonstrated that the timing of the peak of the spring bloom of major zooplankton in the NE Pacific and in the Strait of Georgia has occurred almost two months earlier over the period from the 1960's to the 2000's. This has been due to warmer conditions in both of these areas, which has advanced the physiologies and timing of these key life history events in these zooplankton. Such significant changes in the timing of peak food resources can have important and negative consequences for fish which feed on these animals and which have not changed the timing of their life history processes.

The management of fish resources and aquatic ecosystems is becoming increasingly complex due to a number of climate change impacts: shifting ecosystem dynamics, permafrost thaw and melting Arctic ice, sea level rise, and lessening freshwater quality and availability. Climate-related variations in fish growth and fish stock levels, along with changes in fish species, distribution and migratory patterns, are expected to have economic and social impacts on Canadians living in coastal communities.

### 6.2.3 Water Resources

Canada relies on the availability of a clean, abundant water supply for domestic use; food, energy and industrial production; transportation and recreation; and the maintenance of natural ecosystems. It is estimated that water's measurable contribution to the Canadian economy reaches $7.5 to $23 billion per year. Canada has a relative abundance of water, possessing 7 per cent of the world's renewable freshwater, yet only 0.5 per cent of the global population. However, the water is not evenly distributed across the country, and water availability varies both between years and with the changing seasons. As a result, most regions of the country have experienced water-related problems, such as shortages (droughts), excesses (floods) and associated water quality issues. For example, the drought of 2001/02 affected Canada from coast to coast with significant economic and social impacts; and in the 1990s, severe flooding in the Saguenay region of Quebec (1996) and Manitoba's Red River valley (1997) were two of the costliest natural disasters in Canadian history. More recently, a series of storms on the afternoon of August 19 2005, spawned tornadoes damaging homes in the Conestoga Lake and Fergus areas. The main storm cell just

to the north of Fergus, dubbed the "Toronto Supercell", spawned two F2 strength tornadoes that were particularly damaging, tearing apart trees and farms, as well as overturning automobiles driving on a highway. The storm also produced winds of well over 100 km/h, golf ball sized hail, and flooded many parts of the Greater Toronto Area. Rainfall totals from the storm exceeded 140mm (7") in parts of the north end of the city.

The IPCC's Fourth Assessment Report describes numerous observed climate change impacts on Canadian water resources. Climate warming throughout the 20th century has led to a decrease in total snowfall precipitation in the western region and earlier spring runoff across Canada. Summer flows of the Athabasca River have declined 20 per cent since 1958. Spring river and lake ice break-up in the Northern hemisphere has advanced by 0.2 to 12.9 days over the last 100 years.

### 6.2.4 Fisheries, Oceans and Coastal Zones

Canadian marine fisheries along the Atlantic, Pacific and Arctic coasts and the freshwater fisheries on the Great Lakes have cultural and socio-economic importance to Canada. The fisheries and oceans sector accounts for $20 billion of the Canadian economy, and aquaculture industries contribute $612 million. Canada is the world's six largest exporter of fish and seafood products.

Warmer temperatures are affecting fish distributions, with major implications for marine fisheries, aquaculture production and coastal communities. Numerous aspects of fisheries operations such as transportation, marketing, occupational health and safety, and community health and well-being will be increasingly vulnerable. Aboriginal communities, especially in the Arctic North where fisheries are important part of livelihood, are particularly vulnerable to climate change effects.

Recent studies show pervasive low productivity in Arctic aquatic ecosystems. Although large uncertainties remain about specific ecological responses, it is likely that locally adapted Arctic char species will disappear from certain areas. While extinctions are not expected, some species will be marginalized geographically and/or economically.

Along the Pacific coast, drastic declines in the salmon catch during the 1980s and 1990s have prompted considerable research. The vulnerability of Pacific salmon fisheries is heightened by the unique social, economic and ecological significance of these species. Temperature changes, changes in river flow and temperatures, and extreme climate events affect salmon growth, survival and reproduction, and also have indirect effects on predator-prey dynamics and habitat. Salmon are vulnerable to climate changes both in freshwater rivers (where salmon spawn before migrating upstream) and the marine phases of their life cycle.

Freshwater fisheries are expected to experience higher water temperatures, lower water levels, shifts in seasonal ice cover, and invasion by new and exotic species. Overall, warm-water species would likely benefit, while cold-water species would suffer. Northward migration of fish species and local extinctions are expected, and would lead to changes in sustainable harvests. However, the increasing dominance of warm-water fish species will negatively affect freshwater biodiversity. Higher temperatures and lower water levels are also expected to exacerbate water quality problems, leading to increased fish contamination.

Along the Atlantic coast marine ecosystems also experienced significant changes in the 1990s, with shellfish replacing groundfish as the most valuable catch. Although this shift was driven primarily by fishing practices, climatic changes likely played a role. Future warming trends may impact the shellfish populations on which the region now relies. For example, warmer water temperatures and acidification effects have demonstrated impacts on snow crab reproduction and distribution. There is also concern that the frequency and intensity of toxic algal blooms, which can cause shellfish poisoning, may increase. Other important issues for the Atlantic region include the effects of climate change on salmon and aquaculture operations. Range alterations along the coast need mention, and with them increasing risk of alien invasive species from the south.

Aquaculture in coastal waters could benefit from warmer conditions, with increased growth rates and an increase in the geographic range of the activity. Higher water temperatures and related physical changes could, however, result in more intense and frequent disease outbreaks and algal blooms. Bacterial contamination of oysters and other shellfish may be more frequent as water temperatures rise. The increased frequency of intense winter storms and the trend towards higher wave heights would also physically endanger aquaculture operations.

Ocean acidification is a significant factor for the Pacific and Arctic regions of Canada. The surface ocean currently absorbs approximately one-third of the excess carbon dioxide ($CO_2$) injected into the atmosphere from human fossil fuel use and deforestation, which leads to a reduction in pH and wholesale shifts in seawater carbonate chemistry. The resulting lowering of seawater carbonate ion concentrations and the saturation state for calcium carbonate are well documented in field data, and the rate of change is projected to

increase over the 21st century unless predicted future CO2 emissions are curbed dramatically. Acidification impacts processes so fundamental to the overall structure and function of marine ecosystems that any significant changes could have far-reaching consequences for the oceans of the future and the millions of people that depend on its food and other resources for their livelihoods.

Sea level rise is a significant concern for Canada and is already having clear impacts on ecosystems, as well as human health and infrastructure, in several coastal regions. Accelerated sea-level rise under greenhouse warming is expected to exacerbate climate change impacts, increasing the need for adaptation to minimize damage and costs. Extreme water levels under storm conditions, combined with wave and ice impacts, are exacerbated by rising sea levels, leading to higher frequency of flooding to existing thresholds of damage and the potential for more extreme water levels in future. Coastal erosion rates, already high in many areas, are also expected to accelerate with rising sea levels, less sea ice and more open water during fall or winter storm seasons, and with increased storm intensity. Major storm events in several coastal areas over the past decade have highlighted the high level of vulnerability in coastal communities.

### 6.2.5 Forestry

Canada has more than 400 million hectares of forested land, which is about 40 per cent of the country's total landmass and about 10 per cent of the world's total forest cover. Canada is the world's largest exporter of forest products, and its forest industry contributes almost $30 billion to the country's GDP. In recent years, there have been a number of acute challenges to Canada's forests: for example, severe wildfire seasons in British Columbia and the Yukon (2003 – 2004), mountain pine beetle infestation in the interior forests of British Columbia, the Canadian national drought (2001 – 2002), and reduced winter harvest season length opportunities.

In Northern forest ecosystems – where the boreal forests of the Yukon and Northwest Territories make up about 13 per cent of Canada's total forest cover - the shifting tree line northward, increases in forest fire disturbances, and accelerated permafrost thaw will have impacts on commercial forestry operations, subsistence activities, and traditional cultures and values. For example, wildfire increases may improve soil conditions for mushroom cultivation, but will likely also have negative impacts on woodland caribou.

Climatic events such as heavy winds, storms and drought, and natural disturbances such as wildfire and insect outbreaks are expected to increase in frequency and severity, and will have significant impacts on Canada's forests and the community and economic structures that depend on forest-based resources. Furthermore, changes in climate could also provoke multiple, interacting disturbances with greater impacts than a single disturbance.

Current visible climate effects on forests in Canada include changes in the frequency and severity of natural disturbances (forest fires, drought, severe storms, and insect and disease outbreaks). Other less visible changes are also occurring such as shifts in the timing of spring onset and start of spring blooming. The frequency and severity of extreme weather events and disturbances are expected to increase, and changes in productivity, species composition and age-class distribution are also projected. Productivity is likely to decrease in the areas that are getting drier, but could increase in northern areas that are currently limited by cold temperatures. An important consideration, however, is that forest genotypes tend to be finely adapted to local climates and potential productivity gains may not be realized if forest managers don't match genotypes to suitable climates.

Climate change has implications for both current and future timber supply, in terms of quantity and quality. A higher percentage of the forests will be in younger age classes, and the frequency of early succession species and species adapted to disturbance will increase. The net impact on timber supply will vary from location to location. A significant portion of forest harvests in Canada occur in the wintertime when the ground is frozen; this allows access to wetlands, reduces soil disturbance, and decreases costs of delivered wood. The time window when frozen ground conditions exist will continue to decrease in the future, reducing the length of the winter-harvest season. The magnitudes of climate change impacts that will confront Canada's forests and forest management sector have no historical analogue. Canada's forest sector will need to adapt without prior experience.

A recent study of the 2001/02 drought suggests that it was the most severe drought to strike Canada in several decades. The spatial extent and severity of droughts in the 1920s and 1930s were overall found to be more extreme, though several monitoring stations, mostly in the Prairie provinces, identified the 2001/02 drought as the worst drought since 1915. The extreme drought and dry conditions were experienced simultaneously across Canada from interior British Columbia and the Prairie provinces, southern Ontario and Quebec, and Atlantic Canada. The effects extended to areas traditionally less affected by droughts such as Atlantic

Canada and agricultural areas in the northern Prairies.

### 6.2.6 Human Health

Canada's public health care system has long been a cornerstone of Canadian society. Today, the country spends more than $100 billion on health care services annually. Although health and well-being is influenced by a range of social and economic factors, Canada's variable climatic conditions also play a role. Seasonal trends are apparent in illness and death, while extreme climate events and weather disasters have both acute and chronic health effects. The impacts of future climate change on health and the healthcare sector in Canada are both direct (for example, changes in temperature-related morbidity and mortality) and indirect (for example, shifts in vector-borne diseases). There will be some benefits for human health, as well as many challenges. It is expected that climate change would make it more difficult to maintain our health and well-being in the future. The Canadians who are most vulnerable to impacts from the warming climate are children and infants, the elderly, people with chronic illnesses, socially and economically disadvantaged individuals, communities in Canada's North.

Canada can expect an increased frequency and severity of storms, floods, droughts and forest fires, land slides, avalanches, loss of permafrost and sea ice, and sea inundation that can impose greater stresses on water, food supplies, health, safety, property, well-being and health services. A more variable climate with generally hotter summers and more frequent and severe heat events is expected in Canada. High temperatures can lead to illnesses and deaths due to heat exhaustion, heat stroke and dehydration. Heat can also exacerbate cardiovascular and respiratory illness, diabetes and strokes. It is expected that the risks of heat-related illnesses and deaths will be greatest in densely populated cities due to increased smog and the urban heat island effect. People with respiratory disorders such as asthma will be affected by expected increases in air pollution, and airborne particulates resulting from increased pollen production, dust related to droughts, and more frequent and more severe forest fire disturbances.

Another key concern is that increasing temperatures will be accompanied by extreme precipitation and greater risk on water-borne and food-borne diseases. Previous water-borne infectious disease outbreaks in Canada have been associated with heavy precipitation, snowmelt and flooding. Warmer weather conditions also favour the proliferation of vector-borne diseases such as malaria, West Nile virus and Lyme disease, by encouraging northward expansion in the ranges of arthropod vector species such as the mosquitoes, ticks and fleas, and accelerating pathogen development rates within vectors. From 2002 to 2005, over 1,800 cases of West Nile virus and 46 related deaths were reported in Canada. In 2007, a West Nile virus epidemic in the Prairie provinces was associated with above-average temperatures leading to high mosquito vector abundance.

As Canada's population grows and as climate continues to change the geographical range, frequency and intensity of many existing climate-related hazards are expected to increase. The expected population growth and chronic disease trends indicate that the proportion of Canadians highly sensitive to climate-related health impacts will grow over the coming decades, although this may vary by region and could be influenced by other factors such as access to health care and community support services.

### 6.2.7 Infrastructure and Economy

In recent decades, property and economic damages related to severe weather in Canada, including property damage, lost economic productivity, disruption of physical health, and loss of life have risen dramatically. Many factors have contributed to this increase, including the increasing value of infrastructure at risk. Canada currently invests billions of dollars annually in climate-sensitive infrastructure that must function effectively and safely for many decades. However, in many areas, projected climate changes and impacts are likely to result in higher maintenance and insurance protection costs and rebuilding costs.

In northern Canada, permafrost degradation and coastal erosion are among the key climate change concerns for communities and connecting. Currently, the impacts associated with ground disturbance and construction are expected to be more important in the short term, but over time (decades), the impacts of climate changes on permafrost will become increasingly significant. In some areas, particularly those in areas of ice-rich permafrost, such as those found in parts of the Mackenzie Valley of the Northwest Territories, increases in temperature could significantly impact infrastructure integrity. In coastal areas, reduction in land-fast ice and more open water can result in greatly increased rates of coastal erosion and disrupt coastal infrastructure.

In southern Canada, climate-related disruptions to critical infrastructure, including water treatment and distribution systems, energy generation and transmission, and transportation have occurred in all provinces and are likely to become increasingly frequent in the future. Recent severe flooding has disrupted transportation and communication lines, with damages and costs

associated with individual events exceeding $500 million.

Research studies indicate that the damages and costs of weather-related natural disasters in Canada rose at the end of the 20th century, mainly as a result of the increasing value of infrastructure at risk. Key factors in the increase in infrastructure and property exposure include rising wealth, demographic shifts to coastal areas, rising demand for waterfront property and development land, urbanization in storm-prone areas, sub-standard and aging infrastructure, and inadequate building codes.

### 6.2.8 Transportation

Transportation is an essential element of Canadian economic and social well-being. The main components of our transportation system include the four modes - rail, road, marine and aviation. Assessing the vulnerability of these components to climate change is a key step toward ensuring a safe and efficient transportation system in the future. Climate change is expected to impact transportation primarily through changes in temperature, precipitation, extreme events and water levels. The most vulnerable transportation systems include ice roads, Great Lakes and northern shipping, coastal infrastructure and infrastructure situated on permafrost. Impacts would vary regionally, with both challenges and new opportunities expected. In some cases, benefits would have the potential to outweigh future damages, and a warmer climate may translate into savings for those who build, maintain and use Canada's transportation infrastructure.

In southern regions of Canada, an increase in summer temperature would affect the structural integrity of pavement and railway tracks, through increased pavement deterioration and railway buckling. It is expected, however, that losses incurred in southern Canada during the summer would be outweighed by benefits projected for the winter. Damage to pavement from freeze-thaw events would likely decrease in much of southern Canada, and the costs and accidents associated with winter storms are expected to decline. Changes in precipitation patterns could also affect transportation infrastructure. Future increases in the intensity and frequency of heavy rainfall events would have implications for the design of roads, highways, bridges and culverts with respect to stormwater management, especially in urban areas where roads make up a large proportion of the land surface and where the bulk of transportation activities in Canada occur. Accelerated deterioration of transportation infrastructure, such as bridges and parking garages, may occur where precipitation events become more frequent, particularly in areas that experience acid rain. An increase in debris flows, avalanches and floods due to changes in the frequency and intensity of precipitation events could also threaten transportation systems.

An analysis of deterioration-relevant climate indicators at 17 southern Canadian sites revealed that over the next 50 years, low temperature cracking of southern Canadian road pavement will become less problematic, structures will freeze later and thaw earlier with correspondingly shorter freeze season lengths, although higher pavement temperatures could raise the potential for rutting.

Climate change may lead to changes in the distribution of natural resources and raw materials in Canada and around the world, shifting the location of consumers, producers and the trade routes that connect them. Infrastructure investment decisions, especially those that support strategic gateways and trade corridors, need to be made while taking future transportation demand into consideration.

With respect to Arctic transportation, changes to the polar ice cap may create new economic opportunities – particularly resource exploration and development – along with new navigational and environmental concerns. A scoping study was carried out to identify the impacts that Arctic shipping activity might generate, and the consequences of those impacts. Potential impacts of significant concern identified include: ship incidents or accidents that result in a high risk of pollution or loss of life, such as a crude oil spill; the impact of ships (many making passage through ice) on Arctic community interests and the ecosystems that these communities depend on for their livelihood; and the unpredictability of cruise ship activity, not only in terms of the numbers and timing of such ships but also the locations that they may choose to visit, and their activities in those locations (specifically in relation to wildlife or potential damage to aboriginal sacred lands). In addition to these issues, shorter operating seasons for ice roads will negatively affect community access in parts of the Arctic and sub-Arctic and will increase operating costs for some major economic activities such as diamond mines in the barren grounds. In northern Canada it is well known that melting permafrost is leading roads and air landing strips to buckle. As warming trends continue, impacts on community resupply (ie. a shorter winter road season), the cost of transportation (loss of permafrost and resulting damage to highways and aircraft landing strips), and recreational activities such as snowmobiling (shorter season, more overflow and dangerous conditions) are expected increase. On the other hand, a longer navigational season could benefit coastal Arctic communities by allowing more resup-

ply operations, resulting in better availability of goods and lower prices.

Climate projections for the Great Lakes Basin – a major Canadian transportation corridor – show a potentially significant drop in water levels, with serious implications for available draft and negative impacts on coastal properties, ecosystems, and infrastructure. The hydraulic and environmental impacts of options such as dredging or modifying hydraulic structures have been evaluated via computer modeling. Other options such as reorganizing container traffic elsewhere on the St. Lawrence River are all being examined.

### 6.2.9 Tourism

Canada ranks among the top ten nations for international tourism receipts (US$16 billion) with domestic tourism and outdoor recreation markets that are several times larger. Climate defines the length and quality of tourism seasons and plays a role in destination choice. Climate also induces changes in environmental resources such as snow conditions, water levels and quality, ice conditions and glacier extent, and the diversity of flora and fauna that are inherently linked to the success of a range of tourism sectors.

Climate variability has had both positive and negative impacts on segments of Canada's tourism industry in recent years. Through a series of sector-based and region-based studies carried out between 2006 and 2009, understanding of the projected impacts of climate change on Canada's tourism industry has advanced significantly.

Winter tourism in Canada may be at risk. The alpine skiing, cross country skiing and snowmobiling industries would be negatively impacted by shorter seasons (due to reduced natural snowfalls). These impacts may be offset somewhat by snow-making, assuming access to sufficient amounts of water exists. Under some scenarios, snowmobiling opportunities may be eliminated from parts of Canada as early as the middle of the century.

Warm-weather tourism in Canada is projected to benefit generally from changes in the climate due to longer seasons, yet there may be risks associated with the benefits. For example, golf tourism in many regions of Canada is projected to benefit from longer operational seasons, and the public use of lakes and beaches will also be extended. However, warmer summers may also have a negative impact on water quality (algae growth) contributing to beach closures. Changes to seasonality (e.g., more use of shoulder seasons) at provincial and national parks may also emerge as a result of climate change. The timing and/or design of major tourism events may require changes. For example, the likelihood of tulip maturation aligning with the current timing of Ottawa's Tulip Festival (i.e., May) is projected to be about 50-50 by the middle of the century.

Climate-induced environmental changes could have a significant impact on the tourism industry. For example, glacial retreat may reduce the public accessibility of known iconic natural attractions in Canada's Rocky Mountain national parks (e.g., Columbia Ice fields). Species-dependent events such as bird festivals may be affected, along with the sustainability of local tourism dependent on iconic species such as polar bears in Churchill, Manitoba. However, a shorter ice-free season would provide opportunities to expand tourism nature and cultural tourism in the Arctic region.

In summary, tourism in Canada is sensitive to and very much dependent on the climate. Climate change is projected to create both risks and opportunities for Canada's tourism industry. The timing and magnitude of the impacts of climate change for Canada's tourism industry will vary by geography and by sector, and by the adaptability of individual operators. The projected changes will alter the competitive position of Canada as a tourism destination, and the competitive relationship between individual tourism sectors, tourism destinations, and individual operators within a given sector.

## 6.3 Climate Change Vulnerability Assessments

### 6.3.1 Canadian Impacts and Adaptation Assessment 2007

The Government of Canada led a national-scale scientific assessment of the country's vulnerabilities to climate change and current and possible future adaptations. Through a regional approach, the assessment examined the current and future risks and opportunities presented by climate change, with a focus on human and managed systems. The resulting report, From Impacts to Adaptation: Canada in a Changing Climate 2007 reflects the advances made in understanding Canada's vulnerability to climate change over the past decade and integrated both traditional knowledge and scientific information in its analysis. Key conclusions of the report included: Climate change will exacerbate many current climate risks, and present new risks and opportunities, with significant implications for communities, infrastructure and ecosystems. The report further concludes that moving adaptation forward in Canada involves building on the momentum gained through existing initiatives and considering additional steps to facilitate implementation of adaptation measures and policies.

### 6.3.2 Human Health Vulnerability Assessment 2008

The report, Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity, released in 2008, highlights current and anticipated health impacts of climate change and adaptive capacity in Canada. The development of the report was guided by a National Steering Committee consisting of key experts from federal agencies and organizations across Canada. The report identifies a number of health impacts that are of concern to Canada and those individuals most at risk. The capacity of Canadians to adapt, and knowledge gaps that need to be addressed in order to better understand risks are also discussed. The possible health impacts of climate change on the health and well-being of Canadians includes the spread of vector-borne and zoonotic diseases, an increase in illnesses from worsening air quality and water quality and impacts from more extreme weather events, such as more severe heat-waves. Arctic and northern Aboriginal communities, which are already highly exposed to climate-related health risks, will be increasingly challenged by the warming climatic conditions. Northerners are already reporting environmental changes and corresponding risks to health and well-being associated with a changing climate, and are taking many actions to adapt.

### 6.3.3 Forest Vulnerability Assessment 2007

Canada's forest sector is vulnerable to climate change because of the expected higher magnitudes of climate change at Canada's northern latitude, the sensitivity of Canada's forested ecosystems to climate change, the long growing cycles of trees, and the importance of forests and the forest sector to Canadians from coast to coast. The potential for high impacts, however, is counterbalanced to some degree by a relatively high adaptive capacity in Canada's forest sector. This high adaptive capacity is demonstrated by a number of activities that are beginning in response to climate change. They include (1) enhanced capacity to undertake integrated assessments of vulnerabilities at various scales; (2) relatively strong science capacity in impacts and adaptation; (3) increasing communications, networking, and information exchange in forestry related impacts and adaptation; and (4) some early actions by jurisdictions such as British Columbia to adapt to climate change.

Forest-based communities will likely be increasingly vulnerable to climate change impacts because they have particular economic, social, political and cultural structures that are closely associated with climate-sensitive forest environments. Factors such as small community size, low economic diversity and highly specialized labour forces could hamper the capacity of forest-based communities to adapt. Climate change imposes constraints on the forestry industry and the people who depend on forest-based resources.

Future climate change is expected to strongly affect Canadian forest ecosystems, capacities and resources. In 2007, a partnership was formed between government and the Sustainable Forest Management Network, a Canadian non-profit research organization, to assess forest vulnerabilities across Canada. The resulting report - Climate Change and Canada's Forests: from Impacts to Adaptation - concluded that climate change is already affecting Canada's forests and that future climate change will be further increases in the frequency and severity of extreme weather events and disturbances.

### 6.3.4 Provincially Led Initiatives

A growing number of provincial, territorial and municipal governements throughout Canada are taking a role in vulnerability, impacts and adaptation assessment for issues over which they have partial or complete jurisdiction. Partnerships are often created to allow the development of adaptive capacity for key decision makers who need to implement adaptation within their fields of responsibility. For example, through applied research project and multidisciplinary activities, the Ouranos Consortium has developped a range of products (see www.ouranos.ca) that is allowing the Quebec governement and other users to proactivelly begin to adapt in the context of permafrost degradation, increased coastal zone risks, maladapted infrastructures, water management challenges, energy production and demand management, healthy population and sustainable environment and development.

## 6.4 Adaptation Programs and Measures

The scientific information and findings from Canada's 2007 national vulnerability and impacts assessment provide a solid knowledge base for moving forward with adaptation planning and strategic policy development. Many groups at all levels of government, industry partners, non-governmental organizations, and community organizations, are now making the transition from learning about climate impacts to developing actions and adaptation measures. Federal programming is focused on building knowledge and capacity and preparing for

action to protect ecosystems, human health, Canada's North and infrastructure. Current adaptation initiatives in Canada are promising indications of the determination of Canadians, from individuals to community groups, industry and government, to adapt to the changing climate.

## 6.4.1 Federal Government

### 6.4.1.1 Clean Air Agenda

In 2007, Canada committed C$ 85.9 million for activities under the Adaptation theme of Canadian government's Clean Air Agenda. The theme includes seven programs to assist Canadians in building their capacity to proactively adapt to climate change. The programs support initiatives that develop information, tools, planning and collaborative arrangements to take action on adaptation. While the programs were designed to respond to diverse risks of climate change across Canada and are relevant to many economic sectors and regions, they also target three urgent areas for action – Canada's North, human health and infrastructure.

#### Improved Climate Change Scenarios

Accurate climate information and projections are essential to assess impacts and develop robust adaptation strategies and measures. Environment Canada is focusing on the development of improved climate change projections and scenarios, and research on extreme weather events and hazards for vulnerable infrastructure and for communities across Canada will be carried out. This program is important to enabling Canadians to better plan for atmospheric hazards and improves upon existing infrastructure codes and standards. Key outcomes of this program will include stakeholder based adaptive decision-making, risk reduction, and emergency preparedness programming. The dissemination of the information is done primarily through the Canadian Climate Change Scenarios Network and the Canadian Atmospheric Hazards Network.

#### Assist Northerners in Assessing Key Vulnerabilities and Opportunities

The Assist Northerners in Assessing Key Vulnerabilities and Opportunities program, lead by Indian and Northern Affairs Canada, supports Aboriginal and northern communities, organizations and territories in addressing urgent risks in the North where the impacts of a changing climate are already visible, and vulnerability of infrastructure is high. The program identifies adaptation priorities and builds the strategic actions necessary to address those priorities. The program is focused on working with government organizations, institutions and communities that can ultimately take a lead in assessing and developing management strategies to adapt to the impact of a changing climate. The program supports community planning and adaptive capacity by providing to assist communities undertake risk assessments, including existing infrastructure; engage in adaptation planning; and identify appropriate infrastructure designs and construction to reduce risks due to a changing climate and its impacts.

#### Climate Change and Health Adaptation in Northern First Nation /Inuit Communities

Aboriginal and northern communities and organizations have unique vulnerabilities related to climate change including: health and well-being, sea level rise, melting ice and permafrost, violent storms, community location, sanitation, food safety, water quality, vector-borne diseases, and impacts on wildlife and plants used for traditional diet. This Health Canada program funds community-based projects to enable Northern First Nations and Inuit communities to identify and assess key vulnerabilities and health impacts related to climate change, and then develop innovative and culturally sensitive health risk management plans and tools for adaptation. The communities themselves are leading the assessment and adaptation projects in cooperation with Aboriginal associations, academics, governments and agencies. A key objective is to develop relevant communication materials that will help in decision-making at the community, regional, and national levels with respect to human health. Much of the knowledge and strategies will be transferable to similar communities across the North.

#### Regional Adaptation Collaboratives (RACs)

Collaboration among governments, provinces, communities, businesses, and other stakeholders is essential in order to take effective adaptation action. Natural Resources Canada is establishing collaborative mechanisms, customized to reflect regional needs and expertise, that will focus on applying information and tools to assess adaptation options and share information. Planning for and developing these collaboratives has already helped to galvanize efforts and resources to advance adaptation capacity and policy in several regions.

#### Innovative Risk Management Tools for Adaptation

Decision-makers can effectively use new knowledge on climate change when it is embedded in existing tools

(e.g. guidelines, computer-based analytical models, websites etc.) for risk assessment and management, economic analysis and adaptation planning. A basic suite of tools is being developed in collaboration with industry, practitioners, and government partners, to ensure the safety and competitiveness of communities and economic sectors. Tools developed to date include a risk management guide and a methodology to assess the engineering vulnerability of infrastructure to climate change.

#### Heat and Infectious Disease Alert and Response System

Public health, health care, and emergency response professionals require information to take action and develop adequate strategies to minimize climate-related health risks in Canada. Health Canada and the Public Health Agency of Canada are working with communities, universities and other partners to prepare individuals and communities for extreme heat events and risks from climate-related infectious diseases. The heat resiliency project's objective is to increase knowledge and awareness of the relationship between extreme heat and health through the piloting of heat alert and response systems and the development of information products and tools to support adaptation to extreme heat events in Canada. PHAC component aims to strengthen Canada's public health infrastructure to address health risks associated with vector-borne and waterborne infectious diseases attributed to exacerbated by climate change by a) stimulating knowledge development and transfer, b) building capacity, and c) strengthening national and international public health collaboration.

### 6.4.1.2 Infrastructure Funding Programs

Under the Canada Strategic Infrastructure Fund, funding criteria required projects to demonstrate an awareness of project-specific sensitivities to various climate parameters and of the potential risks posed by future climate changes, thereby addressing the impacts and adaptation component of climate change. In so doing, part of the project assessment for infrastructure projects under this program related to whether the design of the project in question had taken into consideration the impact of potential future climatic events such as increased precipitation.

This criterion has been modified in the successor Building Canada Fund. Under Building Canada, "Disaster Mitigation Infrastructure" has been added as an eligible category of investment to specifically allow funding for the following types of infrastructure projects: a) construction, modification or reinforcement of structures that protect from, prevent or mitigate potential physical damage resulting from extreme natural events, and impacts or events related to climate change; and b) modification, reinforcement or relocation of existing public infrastructure to mitigate the effects of and/or improve resiliency to extreme natural events and impacts or events related to climate change.

### 6.4.1.3 Northern Initiatives

In addition to northern projects under the Clean Air Agenda several other federal initiatives support adaptation in the Canadian North.

During the course of International Polar Year (IPY, 2007-2008) Canadian researchers led 44 different projects, focusing on science for climate change impacts and adaptation, and health and well-being of Northern communities. As a result of IPY research, we are gaining a better understanding of climate change, Arctic Ocean dynamics and declines in sea ice.

In July 2009, Canada's federal government released a Northern Strategy that focuses on exercising Arctic sovereignty, protecting our environmental heritage, promoting social and economic development, and improving and devolving Northern governance. The Northern Strategy recognizes the importance of expanding the science foundation of decision-making – supporting adaptation as well as other policy domains.

Canada's continuing focus on Northern climate change research includes a commitment to a new research station in the High Arctic. Four priority science and technology themes are proposed for the High Arctic Research Station: (1) Sustainable resource development, (2) Environmental science and stewardship, (3) Climate change, and (4) Healthy and sustainable communities. In addition, an Arctic Research Infrastructure Fund has been established to upgrade other key research facilities across the North.

In November 2009, the National Round Table on the Environment and the Economy (NRTEE) released a report titled "True North; Adapting Infrastructure to Climate Change in Northern Canada" which provides advice to the federal government on how to move forward to help northerners adapt their infrastructure to the impacts of climate change. Recommendations focus on integrating climate risks into existing policies and processes, ensuring northern interests are represented in adaptation solutions, and strengthening science and community capacities in Northern Canada. The report was based on three years of research, including consultations across the three northern Canadian territories and engagement with federal and territorial governments, technical experts, scientists, Aboriginal organi-

zations and communities.

Melting sea ice and associated greater ship transport in the Arctic increase environmental and safety and security risks, such as pollution, search and rescue incidents, civil emergencies, and potential illegal activities. International cooperation offers an important way to address some of these challenges. Canada is actively engaged with its northern neighbours – bilaterally as well as multilaterally through institutions like the Arctic Council - to help build a stable, rules-based region that supports economic growth and trade, environmental protection and vibrant, healthy communities. Under Canada's Northern Strategy, the federal government has made commitments to investments that will enhance emergency response capability in the Arctic region, such as a new deep-water berthing and fueling facility in Nanisivik, a new polar icebreaker and Arctic patrol ships.

#### 6.4.1.4 Ecosystem Research Initiatives

Canada has initiated seven Ecosystem Research Initiatives across Canada to explore implementation of ecosystem-based approaches to managing marine resources. The initiatives will provide a better understanding of the linkages among species and the environment and the potential climate change impacts on Canadian ocean ecosystems, towards informing and adapting resource management practices.

It is recognized internationally that protected area networks support the ability of ecosystems to cope with climate change. Natural ecosystems have greater resilience in the face of climate change impacts when additional stresses from industrial and commercial exploitation are reduced, and when species migrating to more suitable locations are facilitated through protected areas. Conservation as part of an adaptation policy is good insurance against the risk of species extinctions due to climate change. The establishment or creation of networks of protected areas can ensure the continued provision of ecosystem services for adaptation, as well as biodiversity conservation.

Canada is designing and establishing a national system of marine protected areas (MPAs) networks in keeping with national and international commitments. Some of the design principles for the MPA network are to ensure its resilience to the effects of climate change by including optimizing size, spacing and shape; spreading risk through representation and replication; protecting critical areas; ensuring connectivity, and maintaining ecosystem function.

#### 6.4.1.5 National Parks and Other Protected Areas

Canada's national parks and other protected heritage areas contribute to climate change adaptation by protecting and restoring healthy, resilient ecosystems, cultural resources, communities, and local economies. Since 2006, Canada has added more than 4 million hectares of land and water to its network of national parks and national marine conservation areas, as well as 30 new national historic sites. In addition, interim protection has been provided to more than 4 million hectares in Canada's North as a key step to the eventual creation of two more national parks. A comprehensive ecological monitoring program has been established. Along with research and modeling, it helps inform proactive adaptation strategies for Canada's national parks and contributes to understanding impacts of climate change on broader land and seascapes. Sound conservation practices that increase the resilience of cultural resources to impacts from climate change have also been supported. In 2008, a comprehensive study was undertaken to assess current knowledge on the effects of climate change on Canada's cultural resources, providing an important baseline and identifying climate change indicators to assist in maintaining the value of our cultural resources into the future.

#### 6.4.1.6 Adaptation Research Tools

A number of other tools have been developed to help facilitate the development of integrated plans for adaptation to climate change. Some examples include: Statistical Downscaling of Global Climate Models, a tool for increasing the resolution of climate models for impact studies; Rapid Assessment of the Impacts of Climate Change (RAICC), an approach linking global climate models to local decision-making; a GIS-based Climate Change Adaptation Decision Support Tool (ADST) for assessing the vulnerability of agriculture to climate change; linking Adaptation, Mitigation and Sustainable Development (AMSD) approaches for synergies; the Canadian Drought Alert and Monitoring Program (CDAMP), a self-analysis tool for drought evaluation through the use of on-site rainfall measurement; and the Atmospheric Hazards Website that assists municipalities in the preparation of their emergency management programs.

#### 6.4.1.7 Other Federal Research Initiatives

The Climate Change Geoscience Program of Natural Resources Canada, now in the 4th year of its current 5-year mandate, has undertaken a wide range of activ-

ities focused on enhancing resilience to climate change in Canada. These have addressed geoscience needs for adaptation in key economic sectors (agriculture, water resources, energy, parks and conservation) and for community adaptation planning. Other areas of effort under this program include remote sensing and ground-based research for climate change impacts detection and monitoring and paleoclimate studies to evaluate past examples of rapid climate change and ecosystem adaptation. Work on community adaptation has partnered with Indian and Northern Affairs Canada, the Government of British Columbia, the Government of Nunavut, numerous municipalities (Delta, Toronto, Halifax, and seven communities in Nunavut), and the Canadian Institute of Planners, among others. A new initiative in the final year of the program is to develop updated projections of sea level rise across Canada, with initial reports completed for Halifax (Nova Scotia) and pilot communities in Nunavut.

### 6.4.2 Provincial and Territorial Jurisdictions

All Canadian provincial and territorial governments are addressing climate change adaptation. Many have included adaptation measures in their climate change strategies. In general, they are at the stage of assessing vulnerabilities and options, not yet taking decisions on implementation. Calls for enhanced collaboration across levels of government, the private sector and non-government organizations are common features appearing in provincial and territorial approaches.

**The Government of the Northwest Territories** has documented current impacts and adaptation actions that GNWT Departments are taking in the 2008 NWT Climate Change Impacts and Adaptation Report. The government is currently working with stakeholders and communities to prepare a NWT Climate Change Adaptation plan and is working with Yukon and Nunavut on common and coordinated planning for adaptation.

**Yukon Government's** Climate Change Action Plan released February 2009, set out seven priority actions. This was to address adaptation out of 33 actions stated in the plan. Community level adaptation funding is occurring in three Yukon communities (Dawson and Whitehorse have started). Five adaptation projects are being funded through INAC in priority areas including: forestry, water quality/quantity, permafrost, climate change scenarios and community information needs and assessments.

**Nunavut's** primary climate change focus is adaptation. Nunavut's initiatives related to adaptation are being supported by INAC. Compiling scientific and local knowledge will be the focus in the next two years. Impacts are being seen on watersheds, coastal communities and permafrost.. A Climate Change Adaptation Plan, developed with support from Natural Resources Canada and the Canadian Institute of Planners, will be released in the coming months. The INAC climate change funding program has been in place since 2006. Pilot studies of impacts and adaptation options have been undertaken in partnership with two communities in each of the three Nunavut regions and with the City of Iqaluit. Impacts are being seen in coastal communities on watersheds, drainage, coastal infrastructure, permafrost and foundation conditions and more broadly on ecosystems and safety in pursuit of traditional lifestyles on the land and sea.

**Newfoundland and Labrador** recently passed two new Acts.

- The Sustainable Development Act, passed in 2007, recognizes the full range of uses and values of natural resources, including traditional resource development (e.g., mining and forestry), habitat for wildlife, parks and wilderness, tourism and recreation; safeguard the life supporting capacity of air, water, soil and ecosystems; provides for the sustainable development of renewable resources in a way that enables people to provide for their economic, social and cultural needs, while preserving the integrity of ecosystems and meeting the reasonably foreseeable needs of future generations; ensures nonrenewable resource developments benefit future as well as present generations by controlling the pace of development; directs departments and agencies to harmonize resource policies which will make them more consistent and efficient in their pursuit of a healthy economy, environment, and society for present and future generations; and ensures that resource decisions address the full range of environmental, social and economic values, and ensure that the views of workers, environmentalists, industry, communities, aboriginal peoples and others have a say in how our resources are managed.
- The Emergency Services Act, passed in 2008, establishes a broad based frame-

work within government for addressing all manners of emergencies in the province, and commits municipalities to developing an emergency plan.

Newfoundland and Labrador recently initiated the development of a province-wide coastal and ocean policy framework and strategic plan to support an integrated approach to coastal and ocean management. Issues being addressed in this framework relate to adaptation policy in coastal areas, and include coastal land use planning; competing needs and interests; coastal and marine infrastructure; social, cultural and economic sustainability; healthy marine environment; public education and awareness; and jurisdiction, regulatory and policy frameworks.

**Prince Edward Island's** provincial government is working interdepartmentally to address adaptation, including using new climatic design values in public works. A risk-based approach to adaptation is included in the province's 2008 Climate Change Strategy, which establishes a provincial, interdepartmental working group to identify and manage current and projected climate-related risks. The group will oversee the development of an adaptation strategy and contribute to the province's involvement in the Atlantic RAC.

**Nova Scotia's** 2009 Climate Change Action Plan contains fifteen actions related to adaptation, including participation in the Atlantic Regional Adaptation Collaborative, an adaptation fund, departmental adaptation planning, an information clearinghouse, an external advisory committee and development of design standards, land-use planning guidelines, a Coastal Development Strategy, a wetlands strategy, a natural capital sustainability strategy and a water resource management strategy, all of which consider climate change impacts.

**New Brunswick's** climate change plan calls for climate change impacts risk and vulnerability assessment and incorporation of climate change considerations into development planning, land and water management practices and emergency preparedness and response. The province will continue to support research and monitoring. Their goal is to "climate-proof" decision-making processes.

**Quebec** has allocated $109 million to adaptation under its Climate Change Action Plan 2006-2012. Efforts focus on health monitoring and warnings, improving water and air quality management, and research and monitoring related to coastal erosion, water, transportation infrastructure, forests, agriculture, permafrost and biodiversity. The Minister of Sustainable Development, Environment and Parks provides public progress reports.

**Ontario** established the Expert Panel on Climate Change Adaptation in December 2007 to provide the government with advice on how best to plan and prepare for the impacts of climate change. The report, publicly released in November 2009, calls for the Government of Ontario to build a climate-resilient province which will be well positioned to adapt to the impacts of climate change.

Examples of recent provincial initiatives include:

- assessing emerging science needs to consider climate change impacts within the source water protection planning process; and,
- conducting leading edge science and research to allow Ontario to better understand and adapt to impacts of climate change on biodiversity and healthy, sustainable ecosystems.

**Manitoba's** Climate Change Action Plan contains over 60 initiatives, of which 10% relate to adaptation. The province is integrating climate change adaptation into environmental assessment and land use instruments and is relocating winter ice roads to land. Manitoba hopes to develop a Climate Change Adaptation Strategy in future, but is currently focused on the Prairie Regional Adaptation Collaborative.

**Saskatchewan** re-introduced The Management and Reduction of Greenhouse Gases Act on December 1, 2009. An Integrated Pilot Study of Watershed Infrastructure Adaptation was completed in 2009 by the University of Saskatchewan with federal, provincial and private sector partners. Work is underway towards the development of a provincial adaptation strategy. Saskatchewan funding support for the Prairie Adaptation Research Collaborative will ensure that the Saskatchewan Government, industry, citizens and other stakeholders have the best possible scientific information on climate change impacts and our provincial adaptation options.

**Alberta** released Phase 1 of its Adaptation Strategy, Internal Framework for the Government of Alberta, in spring 2009, which focuses on risk assessment, capacity building, taking action, evaluating outcomes and strategic integration. A

Climate Change Vulnerability Assessment for Alberta was released in 2008. Alberta participates in the Prairie Regional Adaptation Collaborative.

**British Columbia's** Climate Action Plan includes adaptation, and highlights the provincial commitment to climate change research, protecting forests and water, and helping communities adapt. The Province has established an interagency adaptation committee to provide strategic advice regarding adaptation. Ministries are establishing sector-specific adaptation initiatives; for example the Future Forest Ecosystems Initiative will help adapt forest and range management to a changing climate, and the province is leading work to help coastal communities prepare for sea level rise. In late 2009 B.C. approved a new, comprehensive Adaptation Strategy. adaptation strategy.

In addition to adaptation-specific initiatives, various provincial and territorial programs contain elements related to adapting to new trends in climate extremes and variability, for example: the British Columbia Fire Management Program and Living Water Smart: British Columbia's Water Plan, Alberta's Water for Life Strategy, the Water Conservation Plan in Saskatchewan, the Manitoba Crop Insurance and Sustainable Agriculture Practices Programs, Ontario's Emergency Management and Civil Protection Act, Ontario's Source Water Protection Program, the New Brunswick Coastal Areas Protection Policy, and an "all-hazards" risk assessment program in Newfoundland and Labrador.

### 6.4.3 Communities and Industry

Many municipalities are also attempting to reduce current vulnerability as a result of recent climate trends and extreme events (flooding, forest fires, increasing number of freeze/thaw cycles). The cities of Halifax, Hamilton, Ottawa, Toronto and Vancouver have started to work on ways to incorporate adaptation into their municipal planning and operations.

Municipalities and provinces are actively involved in emergency management and recognize weather related hazards as important considerations when evaluating their risks and preparing plans. Increasing requests from municipalities, provincial flood forecasting authorities, codes and standards authorities and professional associations highlight the need for upgraded climatic design information now to deal with changing climate conditions.

#### City of Toronto

Toronto has responded to the need to address climate change through the Climate Change, Clean Air and Sustainable Energy Action Plan (the "Climate Change Action Plan"), which was unanimously adopted by Toronto City Council in July 2007. The Climate Change Action Plan includes numerous initiatives including the development and establishment of a climate change adaptation strategy. Adaptation actions being considered by the city include programs that reduce the effects of heat waves, flooding from intense rainstorms, high winds, expanding range of insect pests, changes in lake levels and other impacts of climate change.

#### Halifax Regional Municipality (HRM)

Halifax and surrounding communities (now HRM) have been actively addressing climate change issues for several years. More recently, the new long-term Regional Municipal Planning Strategy (RMPS), adopted by Council in 2006, recognized the importance of climate change and the need for a precautionary approach in all planning and development activities. This endorsement of the need for adaptation policy spurred a number of efforts including an extensive LiDAR acquisition project for development of a high-resolution digital elevation model. This is being used to address a wide range of issues, including sea level rise, coastal vulnerability, soil conditions, storm runoff, and urban forestry. Through collaboration with Natural Resources Canada and academic partners, scenarios for sea level rise and future high water levels are providing for simulation of flood hazards and related vulnerability analyses to inform development of the Halifax Harbour Plan. Coastal setback and minimum foundation levels were adopted outside the harbour in the RMPS and a number of planning decisions in the region have already been influenced by the science partnerships and adaptation concerns.

#### Hamlet of Clyde River, Nunavut

This small Inuit community on the east coast of Baffin Island established a community research committee in 2006, which has since developed into Ittaq, the Clyde River Heritage and Research Centre. Ittaq has facilitated and coordinated community-based and external research on climate change impacts in the region and assisted in the development of community adaptation strategies. Ittaq has also partnered with other Arctic communities in Alaska and Greenland in the circumpolar IPY project Siku-Inuit-Hila,

### Engineers Canada and the Public Infrastructure Engineering Vulnerability Committee (PIEVC)

Trends identified by the IPCC cast doubt on the validity of applying historic climate data when designing infrastructure. In the face of climatic changes, engineers may have to reconsider existing assumptions relative to infrastructure capacity and vulnerability. Engineers Canada, a national organization of the 12 provincial and territorial associations that regulate the practice of engineering and license the more than 160,000 professional engineers in Canada, established the Public Infrastructure Engineering Vulnerability Committee to look broadly and systematically at infrastructure vulnerability to climate change from an engineering perspective. The First National Engineering Vulnerability Assessment studied buildings; roads and associated structures; storm water and wastewater systems; and water resources to examine the current state of each infrastructure, availability of climate data and indicators of adaptive capacity. The studies produced an engineering protocol that was evaluated through a pilot project to assess the waterworks system for the City of Portage la Prairie, Manitoba. The Engineering Vulnerability Assessment Protocol is a five-step procedure for sifting through data for developing relevant information on specific elements of the climate and characteristics of a given infrastructure. The Protocol then considers how this information might interact and result in the infrastructure being vulnerable or adaptive to climate change. Engineers Canada has made the Protocol freely available under license to any infrastructure owner who wishes to apply it.

### Canadian Institute of Planners (CIP)

The Canadian Institute of Planners (CIP), the professional body representing 7,000 planners across Canada, launched a Climate Change Impacts and Adaptation Program in 2007. The role of planners is vital to help Canada meet the challenges of climate change. CIP policy advises its members to consider climate change in their actions and recommendations within the broad scope of planning activities in order to minimize risks associated with extreme events and the cumulative effects of climate change; protect natural resources and habitats; ensure no adverse public health effects; build resilience into communities; and take advantage of mitigation and adaptation. CIP is developing Standards of Practice for its members as well as tools, training and information to assist them in this.

### Transportation Association of Canada (TAC) Climate Change Task Force

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, secure, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The Association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices.

Recognizing that climate change is an important issue for all Canadians, and that the transportation sector both contributes to and is affected by climate change, the Association created a Climate Change Task Force to provide a forum for the discussion of climate change issues in the transportation sector. The Task Force's priorities include raising awareness of the importance of climate change amongst TAC members, providing leadership on the topic of climate change for its extensive volunteer network, advancing the understanding of the importance of high quality climatic data, highlighting the economic implications of climate change, and addressing climate change mitigation and adaptation in TAC products, especially its technical guidelines and best practices.

### City of Yellowknife

The City of Yellowknife joined the Partners for Climate Protection and made the commitment to reduce greenhouse gas emissions within municipal operations by 20% below 2004 levels by 2014, by 6% within the entire city over the same time period. The base year of 2004 was selected as that was the year after the City switched from diesel to hydro electricity. The City has completed a feasibility study examining the potential of using an abandon mine located within the community as a thermal reservoir, supplying heat to a district energy system in the downtown core.

The City of Yellowknife is the first municipality in the Canada to pass minimum level energy efficiency standards for commercial buildings (25% better then the Model National Building Code) and requires new homes achieve a 80 score on EnerGuide for Homes rating system. In 2009 Corporate Nights Magazine named Yellowknife Canada's most sustainable small city for the second year in a row.

### Quebec

In Quebec, the "Climat Municipalités" program offers financial support to cities and municipalities who wish to develop their own plans for adapting to local climate

change impacts. Owing to this program, Quebec City, which had already developed an adaptation plan for its environment service, is about to extend its plan to all municipal services. The cities of Montreal and Trois Rivières are also developing such action plans. In fact, a guide aimed at accompanying municipalities during the development of their adaptation strategy was created by the Ouranos consortium, in cooperation with the Government of Quebec. Also note that the municipality of Sept-Iles carried out a detailed cost-benefit analysis taking into account flooding and coastal erosion scenarios in order to adjust its management of these coastal zones accordingly.

### 6.4.4 Collaboration on International Adaptation

Recognizing climate change is a global problem requiring international cooperation and action, Canada has continued to remain engaged with international institutions and regional bodies to address and research issues surrounding the impacts of climate change and required adaptation processes. Further, Canada has supported a number of climate change vulnerability, impacts and adaptation activities in China, Africa, the Americas and the Polar Region.

#### Climate Change Impacts and Adaptation in the Polar Region

Dramatic changes are occurring in the Arctic due to climate change, including increased shipping activity and the development of natural resources as sea ice continues to melt. In response to these pressures, Canada is a member of the Arctic Council, a high-level intergovernmental forum that provides a mechanism to address the common concerns and challenges faced by the Arctic Governments and the Indigenous Peoples of the Arctic. The Arctic Council Working Group for the Protection of the Arctic Marine Environment (PAME) considers the impacts of climate change in future projects with the intention to inform and advise decision-makers of important issues and trends. The Group conducted the Arctic Marine Shipping Assessment, and updated the Offshore Oil and Gas Guidelines and Regional Programme of Action for the Protection of the Arctic Marine Environment from Land-based Activities which have defined a set of recommended practices and outlined strategic actions for consideration by those responsible for the regulation of offshore oil and gas activities (including transportation and related onshore activities) in the Arctic. Canada is also represented on the International Arctic Science Committee, which coordinates international collaboration on circumpolar science priorities, including climate change impacts on Arctic ecosystems and communities.

## 6.5 Future Activities

Over the past reporting period, Canada has made significant progress on assessing and understanding vulnerability to various aspects of a changing climate and on implementing adaptation initiatives with a particular focus on the three areas of human health, Canada's north and infrastructure.

Over the coming years Canada will continue to strengthen its knowledge base in order to improve the understanding of climate change impacts and vulnerability, develop and refine tools to facilitate effective adaptation decision-making at all levels, and build regional collaboration. Further opportunities for integrating adaptation into decision-making will be sought, building on various approaches, including ecosystem-based and community-based adaptation and strategic environmental assessment.

## 6.6 References

Arctic Council. 2009. Arctic Offshore Oil And Gas Guidelines. Protection Of The Arctic MarineEnvironment Working Group. 98p.

Auld, H. 2008. Disaster risk reduction under current and changing climate conditions. WMO Bulletin 57(2).

Comer, N., A. Fenech and W. Gough. 2007. "Selecting a Global Climate Model for Understanding Future Scenarios of Climate Change" in Fenech, A. and J. MacLellan. 2007. Linking Climate Models to Policy and Decision-Making. Environment Canada. Toronto, Ontario, Canada.

D'Arcy P., J.F. Bibeault and R. Raffa. 2005. Changements climatiques et transport maritime sur le Saint-Laurent. ...tude exploratoire d'options d'adaptation. Ouranos Consortium on Regional Climatology and Adaptation to Climate Change. Quebec, Canada. 140p.

Doney, S. C., Fabry, V.J., Feely, R.A., Kleypas, J.A. (2009). "Ocean Acidification: The Other CO2 Problem." Annual Review of Marine Science 1: 169-192, doi:10.1146/annurev.marine.010908.163834.

Environment Canada. 2006. Impacts of Sea Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick: Executive Summary. Government of Canada. Ottawa, Ontario. 28p.

Fenech, A. and J. MacLellan. 2007. "Rapid Assessment of the Impacts of Climate Change: Building Past and Future Histories of Climate Extremes" in Fenech, A. and J. MacLellan. 2007. Linking Climate Models to Policy and Decision-Making. Environment Canada. Toronto, Ontario, Canada.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Fleury M, Charron DF, Holt JD, Allen OB, Maarouf AR. 2006 A time series analysis of the relationship of ambient temperature and common bacterial enteric infections in two Canadian provinces. Int J Biometeorol. 50, 385-391.

Forbes, D.L., G.K. Manson, J. Charles, K.R. Thompson and R.B. Taylor. 2009. Halifax Harbour extreme water levels in the context of climate change: scenarios for a 100-year planning horizon. Natural Resources Canada, Geological Survey of Canada, Open File 6346, 22 p.

Gachon, P. and Y. Dibike. 2007. Temperature change signals in northern Canada: convergence of statistical downscaling results using two driving GCMs in Int. J. Climatol. 27: 1623–1641 (2007)

Hodgson, J.R.F., J.G, Calvesbert and M. Winterbottom. 2008. Arctic Shipping Impact Assessment: Scoping Study. Marine Affairs Program, Dalhousie University. Halifax, Nova Scotia, Canada. 103 p.

Jones, B. and Scott, D. 2006. Climate change, seasonality and visitation to Canada's national parks. Journal of Park and Recreation Administration 24(2), 42–62.

Lemmen, D.S.,Warren, F.J. and J. Lacroix. 2008. From Impacts to Adaptation: Canada in a Changing Climate 2007, edited by D.S. Lemmen, F.J.Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON, p. 1-20.

Lemmen, D.S. and F.J Warren. 2004. Climate Change Impacts and Adaptation: A Canadian Perspective. Climate Change Impacts and Adaptation Directorate, Natural Resources Canada. Ottawa, Ontario. 201p.

Lemprière, T.C.; Bernier, P.Y.; Carroll, A.L.; Flannigan, M.D.; Gilsenan, R.P.; McKenney, D.W.; Hogg, E.H.; Pedlar, J.H.; Blain, D. 2008. The importance of forest sector adaptation to climate change. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, AB. Inf. Rep. NOR-X-416E

Mills, Brian N., Susan L. Tighe, Jean Andrey, James T. Smith, and Ken Huen. Climate Change Implications for Flexible Pavement Design and Performance in Southern Canada. ASCE Journal of Transportation Engineering (submitted)

Minister of Indian Affairs and Northern Development and the Federal Interlocutor for Métis and Non-Status Indians. 2009. Canada's Northern Strategy: Our North, Our Heritage, Our Future. Ottawa.

Ogden, N.H., Maarouf, A., Barker, I.K., Bigras-Poulin, M., Lindsay, L.R., Morshed, M.G., O'Callaghan, C.J., Ramay, F., Waltner-Toews, D. & Charron, D.F. 2006. Climate change and the potential for range expansion of the Lyme disease vector Ixodes scapularis, in Canada. International Journal for Parasitology, 36, 63-70.

Parks Canada and the Canadian Parks Council. 2008. Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas. Ottawa.

Schuster, C.J., Ellis, A.G., Robertson, W.J., Charron, D.F., Aramini, J.J., et al. (2005). Infectious disease outbreaks related to drinking water in Canada, 1974-2001. Canadian Journal of Public Health, 96(4), 254-258.

Scott, D. 2006. Climate change and sustainable tourism in the 21st century. In J. Cukier (ed.) Tourism Research: Policy, Planning, and Prospects. Waterloo, ON: Department of Geography Publication Series, University of Waterloo.

Scott, D., McBoyle, G., and Minogue, A. 2006. Climate Change and the Sustainability of Ski-based Tourism in Eastern North America: A Reassessment. Journal of Sustainable Tourism 14, 4: 376–398.

Séguin, J. and P. Berry. 2007. Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity - Synthesis Report. Health Canada. Ottawa, Ontario, Canada. 26p.

Thomas, M.K., Charron, D.F., Waltner-Toews, D., Schuster, C.J., Maarouf, A.R., et al. (2006). A role of high impact weather events in waterborne disease outbreaks in Canada, 1975-2001. International Journal of Environmental Health Research, 16(3), 167-180.

Wheaton, E., G. Koshida, B. Bonsal, T. Johnston, W. Richards, V. Wittrock. 2007. Synthesis Report: Agricultural Adaptation to Drought in Canada: The Case of 2001 to 2002. Saskatchewan Research Council. SRC Publication No. 11927-1E07. 38p.

Williamson, T.B.; Colombo, S.J.; Duinker, P.N.; Gray, P.A.; Hennessey, R.J.; Houle, D.; Johnston, M.H.; Ogden, A.E.; Spittlehouse, D.L. 2009. Climate change and Canada's forests: from impacts to adaptation. Natural Resources Canada, Canadian Forest Service, Northern Forest Research Centre, Edmonton, Alberta, Sustainable Forest Management Network, University of Alberta, Edmonton, Alberta. 112p.

# Chapter 7

# Financial Resources and Transfer of Technology

## 7.1 Provision of "new and additional" resources

Preventing climate change is a global challenge that requires a global solution. Canada supports international efforts to address climate change in developing countries through various multilateral, bilateral and partnership channels.

Canada's most recent significant provision of new and additional resources is its contribution of CAD$100 million to the World Bank's Pilot Program for Climate Resilience (PPCR) in 2008-2009. The goal of the PPCR is to support national-level planning for adaptation to climate change in the poorest and most vulnerable developing countries. The pilot program is also expected to provide important lessons to the Canadian International Development Agency (CIDA) on integrating climate resilience and adaptation into the development and rollout of country and regional program strategies.

Canada also continues to support climate change activities through its assessed and regular contributions to the Global Environment Facility (GEF) - currently CAD$145 million over 2006-2010 for the 4th replenishment period, of which approximately one-third supports climate change activity. Since submission of its 4th National Communication, Canada has contributed CAD$13.5 million to the Special Climate Change Fund (SCCF) under the UNFCCC and administered by the GEF. Canada's contributions to the GEF are new and additional to its ongoing development assistance. (Table 7.1)

Consistent with Canada's commitment to the 2009 Copenhagen Accord, Canada will contribute its fair share to the total developed country contribution of US $30 billion for the period 2010-2012 in support of mitigation and adaptation in developing countries. Canada will also work with partner countries to mobilize US $100 billion per year by 2020 from private and public funds in support of climate change action in developing countries.

Canada's financial support to address climate change has primarily been delivered through multilateral channels (Figure 7.1). Canada's multilateral activities on climate change largely consist of its contribution to the World Bank PPCR ($100 million over 2008/09 - 2009/10) and Canada's assessed contributions to the Global Environment Facility (GEF) Replenishment, approximately $36 million/year (of which the GEF directs approximately one third, or $12 million/year, to its climate change focal area).

Within Canada's geographic programming on climate change, efforts have been primarily focussed on Asia followed by the Americas with limited programming in Africa and Europe, Middle East and Maghreb (Figure 7.2). This is due to the large amount of climate change programming channelled towards China. China has received almost three times more climate change funding than any other CIDA bilateral or regional program and represents almost 25% of CIDA total geographic programming in climate change.

Figure 7.2 is an illustrative table of Canada's recent international climate change support including select projects, programs and commitments.

As demonstrated in the Tables 7.2 and 7.3, while Canada's financial support to address climate change has been primarily delivered through multilateral channels, it also includes significant bilateral and international partnership activities across a range of mitigation and adaptation activities such as capacity building, forestry, agriculture, clean technology, etc.

## 7.2 Adaptation Assistance to developing country parties that are particularly vulnerable to climate change

Canada's efforts to support adaptation in developing countries aim to reduce vulnerability, enhance resilience and build adaptive capacity to prepare for or respond to the observed or projected impacts of climate change. This includes measures to address prolonged periods of drought, increased frequency or intensity of extreme weather events, food and water insecurity, the spread of infectious disease, and sea level rise. Canada's assistance targets on-the-ground activities at the household and community-levels as well as strategic, national level efforts in adaptation planning.

| | 2005/2006 | 2006/2007 | 2007/2008 | 2008/2009 |
|---|---|---|---|---|
| | CAD$ Million | | | |
| Global Environment Facility | 70.32 | 9.15 | 36.27 | 36.27 |

Table 7.1: Financial Contributions to the Global Environment Facility (GEF)

| | Partner | Year | Total |
|---|---|---|---|
| | | | CAD$ Million |
| **Adaptation** | | | |
| Pilot Program for Climate Resilience | Multilateral – World Bank | 2008-2010 | 100 |
| Caribbean Disaster Risk Management Program | Multilateral – World Bank | 2007-2015 | 20 |
| Global Facility for Disaster Risk Reduction: Track II | Multilateral – World Bank | 2006 | 3.5 |
| GEF: SCCF – Adaptation | Multilateral – Global Environment Facility | 2005-2007 | 11 |
| Building Response to Climate Change in Nigeria | Bilateral | 2007-2012 | 5 |
| Tomini Bay Sustainable Coastal Livelihoods and Management | Bilateral | 2007-2012 | 4.7 |
| Sahara and Sahel Observatory | Bilateral | 2005-2009 | 3.3 |
| International Research Initiative on Adaptation to Climate Change. | International Partnership | 2010-2015 | 6.25 |
| Adaptation in Africa | International Partnership | 2006-2012 | 15 |
| Climate Change, Agriculture and Food Security" Challenge Program - CGIAR | International Partnership | 2010-2012 | 5.5 |
| **Mitigation** | | | |
| GEF Trust Fund | Multilateral – Global Environment Facility | 2006-2010 | 48 |
| GEF: SCCF - Technology | Multilateral – Global Environment Facility | 2007-2009 | 2.5 |
| African Model Forest Initiative | Bilateral | 2009-2012 | 15 |
| Olade Sustainable Energy Project | Bilateral | 2002-2010 | 4.8 |
| Technology Early Action Measures (TEAM) | Bilateral | 2006-2009 | 7.1 |
| Global Alliance on Agricultural Greenhouse Gases | International partnership | 2010-2015 | 27 |
| Asia-Pacific Partnership on Clean Development and Climate | International Partnership | 2009-2011 | 12 |
| Methane to Markets (M2M) | International Partnership | 2009-2010 | 0.7 |
| Renewable Energy & Energy Efficiency Partnership (REEEP) | International partnership | 2009-2011 | 0.2 |

Table 7.2: Highlights of Recent Canadian International Climate Change Support

| | Partner | Year | Total |
|---|---|---|---|
| | | | CAD |
| **UNFCCC Technical and Financial Support** | | | |
| UNFCCC Contribution to Core Budget | Multilateral - UNFCCC | Annual | $1 Million |
| UNFCCC ITL | Multilateral - UNFCCC | Annual | $0.25 Million |
| UNFCCC supplementary (support for Copenhagen) | Multilateral - UNFCCC | 2009 | $0.30 Million |
| Least Developed Country Expert Group (LEG) | Multilateral - UNFCCC | 2008-2010 | $0.13 Million plus Canadian Member |
| Nairobi Work Program (NWP) | Multilateral - UNFCCC | 2008 | $0.25 Million |
| Expert Group on Technology Transfer (EGTT) | Multilateral - UNFCCC | | $0.40 Million in 2008 plus $0.20 Million annually plus Canadian Member |
| Least Developed Country Group - Support for 2009 Negotiations | Bilateral | 2009 | $0.40 Million |

Table 7.3: Other Climate Change Related Support

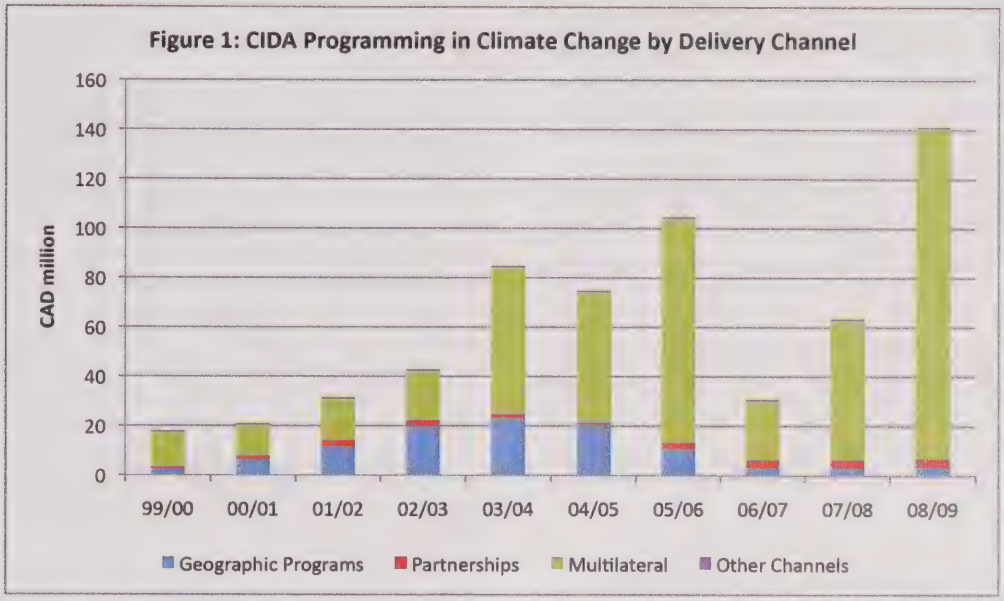


Figure 7.1: CIDA Programming in Climate Change by Delivery Channel

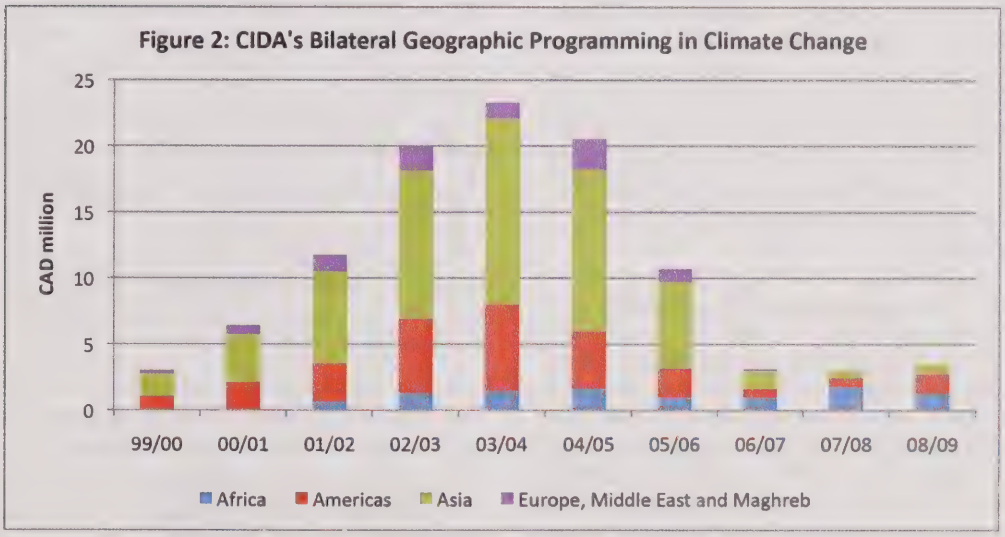


Figure 7.2: CIDA's Bilateral Geographic Programming in Climate Change

### Caribbean Disaster Risk Management Program 2007-2015 CAD$20 Million

The goal of the Caribbean Disaster Risk Management Program is to increase the capacity of regional organizations, national governments and local communities in the Caribbean to respond to and manage natural disasters such as hurricanes and floods and to reduce their impact on the people of the region. It supports the implementation of the disaster risk management framework adopted by the member states of the Caribbean Community (CARICOM).

The project is in the form of a responsive fund worth CAD$20 million in total. The fund supports initiatives led by organizations such as the Caribbean Disaster Emergency Response Agency (CDERA) that improve coordination and disaster preparedness at local, national, and regional levels and that encourage the integration of disaster risk management into policies, planning, and decision-making in the public and private sectors.

### Canada-China Cooperation in Climate Change Project

The Canada-China cooperation in Climate Change (C5) Project is organized around four components: awareness and outreach, national communication, adaptation and impacts and clean development mechanism. The most significant benefits of the C5 Project include an increased ability for China to address the issue of climate change (from emissions reductions through to adaptation), and the improved abilities for Chinese organizations and individuals to make decisions and take action that include climate change considerations. New domestic and international partnerships have been developed, and stronger foundations have been laid to address the issue of climate change more effectively, while gaining positive environmental, social and economic benefits.

The success of the Awareness and Outreach Component is a prime example of how C5 helped build professional skills for women and men while getting the climate change message to the public, and youth in particular. The C5 project also resulted in numerous benefits for Canada. Environment Canada's well-established relationship with China has been furthered with new trust and relationships as well as technical transfers in the areas of drought and agricultural adaptive capacity assessment. These benefits will reach into the future as Canada's researchers have a better understanding of considerations for developing countries, as businesses serving climate change needs can better market their products, and indirectly as another country becomes more capable of addressing the global challenge of climate change.

### Building Climate Change Adaptive Capacity in Western Africa

This project supports the AGRHYMET Regional Centre (ARC) in Western Africa in its mission to make people less vulnerable to the effects of climate change and to protect the environment. The AGRHYMET Regional Centre is a specialized institution of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), which has nine member countries: Burkina Faso, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger, and Senegal. ARC's objective is to produce, disseminate, and manage information about food security, combating desertification and managing renewable natural resources. The centre carries out training and information programs. Canada's project focuses on building their adaptive capacity to climate change in the region through defining a framework for vulnerability, impacts and adaptation studies in the Sahel region, support for managing social and climate databases for these studies, developing methods for analyzing the precipitation regime in the regime, and validating climate models for the region.

### Climate Change Adaptation in Africa

The CCAA is a joint program of the International Development Research Centre (IDRC), Canada, and the Department for International Development (DFID), U.K.

The Climate Change Adaptation in Africa (CCAA) research and capacity development program aims to improve the capacity of African countries to adapt to climate change in ways that benefit the most vulnerable. Building on existing initiatives and past experience, the CCAA program works to establish a self-sustained skilled body of expertise in Africa to enhance the ability of African countries to adapt.

The purpose of the CCAA is to significantly improve the capacity of African countries to adapt to climate change in ways that benefit the most vulnerable. Four objectives support this purpose:

- To strengthen the capacity of African scientists, organizations, decision makers and others to contribute to adaptation to climate change.
- To support adaptation by rural and urban people, particularly the most vulnerable, through action research.
- To generate a better shared understanding of the findings of scientists and research institutes on climate variability and change.

- To inform policy processes with good quality science-based knowledge

#### Climate Change and Biodiversity in the Americas

The changing climate is a significant driver of biodiversity and is already altering many ecosystems throughout the Americas. It is necessary to prevent and mitigate these changes to preserve the biodiversity and ecological integrity of the region. In order to begin addressing these issues, CIDA funded Environment Canada and the Smithsonian Institution to co-host an international science symposium titled Climate Change and Biodiversity in the Americas at the Smithsonian Tropical Research Institute in Panama City, Panama. The goals of the symposium were to: review the baseline data and systematic observation networks to assess biodiversity conservation and policy responses to global climate change; integrate our knowledge of likely future changes on forest biodiversity from a changing climate; report on predictive models and decision support tools to guide the design and selection of adaptation strategies from local to regional scales; and establish a framework for future collaborative research on climate change and biodiversity. The symposium brought together top researchers, industry representatives and managers of climate change and forest biodiversity research and monitoring activities from 21 countries in North, Central and South America, as well as the Caribbean.

#### Climate Change Impacts and Adaptation in the Polar Region

Dramatic changes are occurring in the Arctic due to climate change, including increased shipping activity and the development of natural resources as sea ice continues to melt. In response to these pressures, Canada is a member of the Arctic Council, a high-level intergovernmental forum that provides a mechanism to address the common concerns and challenges faced by the Arctic Governments and the Indigenous Peoples of the Arctic. The Arctic Council Working Group for the Protection of the Arctic Marine Environment (PAME) considers the impacts of climate change in future projects with the intention to inform and advise decision-makers of important issues and trends. The Group conducted the Arctic Marine Shipping Assessment, and updated the Offshore Oil and Gas Guidelines and Regional Programme of Action for the Protection of the Arctic Marine Environment from Land-based Activities which have defined a set of recommended practices and outlined strategic actions for consideration by those responsible for the regulation of offshore oil and gas activities (including transportation and related onshore activities) in the Arctic. Canada is also represented on the International Arctic Science Committee, which coordinates international collaboration on circumpolar science priorities, including climate change impacts on Arctic ecosystems and communities.

#### Nairobi Work Programme

The UNFCCC Nairobi Work Programme on impacts, vulnerability and adaptation is a five year program of work established in order to assist countries to improve their understanding and assessment of impacts, vulnerability and adaptation, and to make informed decisions on practical actions and measures to respond to climate change. Canada has contributed actively to the UNFCCC Nairobi Work Programme since its inception both through the provision of financial support and through the provision of expert support for participation in workshops and publications.

## 7.3 Activities related to the transfer of technology

Canada is engaged in international climate change technology innovation and diffusion through both multilateral and bilateral channels. Canada's previous approach to engaging with developing countries focused on technology assistance through development programs such as the CCCDF. More recently, the government of Canada has increased peer-to-peer collaboration with emerging economies. Engaging emerging economies is a priority for Canada, as they are projected to be the sources of most of the increase in GHG emissions. Emerging economies have the opportunity to avoid following a high emission path with the use of low-carbon technologies developed internally as well as through the transfer of low-carbon technologies that are developed within Canada and other Annex I countries.

### 7.3.1 Multilateral engagement

Canada engages with key international organizations like the International Energy Agency (IEA), Organization for Economic Cooperation and Development (OECD), and the Asia-Pacific Partnership on Clean Development and Climate (APP) to facilitate technology cooperation.

#### 7.3.1.1 International Energy Agency

The IEA has 42 implementing agreements to encourage technology collaboration among members. Canada

participates in 34 of these agreements covering the entire technology research-to-diffusion spectrum. Canada provides $500,000 annually to the IEA, with additional funds at targeted agreements, such as the IEA Climate Technology Initiative. These agreements form the framework for facilitating initiation, implementation, monitoring and review of collaborative R&D between developed countries and emerging developing countries in renewable energy, energy end use, fossil fuels, information centres and modelling, and nuclear fusion.

#### 7.3.1.2 Asia-Pacific Partnership on Clean Development and Climate

The APP is a public-private partnership initiative created to address the issues of sustainable development, clean energy and climate change through the development, deployment and diffusion of clean, efficient and climate-friendly technologies. The APP's approach emphasizes practical actions in cooperation with the private sector. Given the magnitude of investment and innovation sources required to deploy technology is beyond the reach of governments, it is vital for governments to involve the private sector to leverage the scale of financing needed. The APP includes Australia, Canada, China, India, Japan, Republic of Korea, and the United States. Canada has committed $20M to this initiative between 2007 and 2011.

#### 7.3.1.3 Poznan Strategic Program for Technology Transfer

Canada looks forward to the implementation of the GEF's Poznan Strategic Program for Technology Transfer. This program will be funded in part from the technology portion of the Special Climate Change Fund (SCCF) under the UNFCCC, for which Canada is one of the largest donors[1].

#### 7.3.1.4 Technology Early Action Measures

Technology Early Action Measures (TEAM) was a Government of Canada interdepartmental technology investment program that began in 1998. During its 10-year history, TEAM brought together private and public sector partners, and identified, developed and supported the most promising environmentally sound technologies with the greatest potential to reduce greenhouse gases (GHGs). TEAM brought 140 technology demonstration projects to reality in Canada and around the world. TEAM's $129 million in investments was leveraged into over $1.15 billion, with nearly $800 million coming from Canadian private companies. Of these projects, 21 had international components, reaching 15 countries. Over its lifetime, TEAM leveraged $22 million from foreign governments and $27 million from foreign private companies. Between 2006 and 2009, TEAM provided over $7.1 million in funding for international projects in India, Cuba, the United Arab Emirates, Argentina and the United States of America. TEAM has transitioned to the Government of Canada's new ecoACTION program under the ecoENERGY Technology Initiative.

#### 7.3.1.5 The Expert Group on Technology Transfer

The UNFCCC provides a strong platform to encourage greater collaboration amongst Parties in technology development and deployment. The Expert Group on Technology Transfer (EGTT) brings together national level expertise within the UNFCCC that provides guidance to Parties on issues regarding the development and transfer of environmentally sound technologies while respecting Parties' rights and obligations to determine, implement and execute technology strategies appropriate to their specific circumstances. Among its various deliverables, the Guidebook on preparing technology transfer projects for financing has provided a practical tool to project practitioners, and facilitated links between technology projects and private financing sources allowing these projects to move ahead. Canada has an elected representative on the EGTT, and provides $40,000 in 2008 to support developing country participation in the EGTT, as well as contributes $20,000 annually for membership.

#### 7.3.1.6 Climate Adaptation in Africa

Canada's International Development and Research Centre (IDRC) jointly funds the Climate Change Adaptation in Africa (CCAA) program with the United Kingdom's Department for International Development (DfID). The CCAA program works to establish a self-sustained skilled body of expertise in Africa to enhance the ability of African countries to adapt to the adverse effects of climate change. Through this program, Canada is investing $15 million between 2006 and 2012 to ensure that research institutions are better able to assess climate-related vulnerability and develop adaptation options.

[1] As of 4 March 2008, Canada has contributed CAD $13.5 million to the SCCF, of which CAD $2.5 million is for the Program for Transfer of Technology. The remainder is for the Program for Adaptation.

#### 7.3.1.7 International Partnership for Energy Efficiency Cooperation

Canada, its G8 partners, the European Commission and the Governments of China, India and South Korea signed the International Partnership on Energy Efficiency Cooperation (IPEEC) at the 2008 G8 Meeting. IPEEC, launched in May 2009 and hosted by the IEA, aims to facilitate actions that yield high energy efficiency gains. It will provide a forum for discussion, consultation and information exchange on energy efficiency, including building codes, energy-using product and services standards, and tools for the financing of energy efficiency measures. IPEEC has outlined five projects: the Sustainable Buildings Network task group; the Energy Management Action Network for Industrial Energy Efficiency; the Assessment of Energy Efficiency Financing Mechanisms; the Global Energy Efficiency Action Initiative; and a project on improving public and private sector methods for measuring and verifying energy efficiency improvements.

#### 7.3.1.8 Generation IV International Forum

Canada is working, through the Generation IV International Forum on Nuclear Power (Gen IV), with other countries to develop the next generation of commercial nuclear energy systems. Countries that participate alongside Canada include the US, France, Switzerland, China, Korea, Japan and South Africa. In 2008-09, the Canadian government provided $4.9 million in financial support for Gen IV, while Atomic Energy Canada Limited, a Crown Corporation, provided a further $2.6 million in kind.

#### 7.3.1.9 North American Energy Working Group

Canada engages in energy science and technology partnerships with the United States and Mexico under the auspices of the North American Energy Working Group (NAEWG). The goals of the NAEWG are to foster communication and cooperation among the governments and energy sectors of the three countries on energy-related matters of common interest. There are now nine working groups under the NAEWG, on topics including oil sands, energy efficiency and science and technology.

Canada, the United States and Mexico, under the North American Energy Working Group (NAEWG), signed an Agreement for Cooperation in Energy Science and Technology in July 2007. The Agreement provides an umbrella for bilateral and trilateral cooperation in the areas of renewable energy, energy efficiency, nuclear energy, fossil fuels and electricity, with a view to advancing science and technology in areas including low, or zero emission energy production, low carbon fuels; technology for cyber security related to energy infrastructure; carbon dioxide ($CO_2$) sequestration; energy-related fundamental science; hydrogen and fuel cell technologies; electricity generation, storage and transmission; and energy security planning tools.

The agreement is in force for five years and shall be automatically renewed for further five year periods. The forms of cooperation in this Agreement include execution of bilateral/trilateral studies, projects or experiments; exchange and provision of information and data on scientific and technical activities; exchange of scientists, engineers and other specialists for agreed periods of time in order to participate in energy-related analysis, research and development; meetings in various forms to discuss and exchange information on energy science and technology; and development of networks for efficient communication and information exchange among/between the three governments and the public/private sectors.

#### 7.3.1.10 International Science and Technology Partnerships

To support the development of stronger science and technology relationships with key countries and jurisdictions, including China, India, Brazil, Isreal, and California, Canada established the International Science and Technology Partnerships Inc. (ISTP), and committed $13.5 million between 2005 and 2009 for technology cooperation with these countries and jurisdictions. Climate change related projects include work on increasing fuel efficiency and use of biofuels in India and research and development of tidal and wave energy in China.

#### 7.3.1.11 Global Bioenergy Partnership

The Global Bioenergy Partnership (GBeP) provides a mechanism for international cooperation on research, development, demonstration and commercial activities related to the production, delivery, conversion and use of biomass for energy, with a particular focus on developing countries. GBeP also provides a forum for identifying effective policy frameworks and means to support investments and the removal of barriers to collaborative project development and implementation.

#### 7.3.1.12 Renewable Energy & Energy Efficiency Partnership

The Renewable Energy & Energy Efficiency Partnership (REEEP) is a global partnership with the aim of reducing policy, regulatory and financial barriers that limit the

uptake of renewable energy and energy efficiency technologies and projects. REEEP works with governments, businesses, industry, financiers and civil society across the world to expand the global market for renewable energy and energy efficiency technologies.

#### 7.3.1.13 Methane to Markets Partnership

Canada is a member of the Methane to Markets Partnership (M2M), a voluntary international cooperative initiative to address fugitive emissions of methane from four major sources: agriculture, coal mines, landfills, and oil and gas systems. The Partnership encourages market-oriented clean energy technology solutions that address climate change and energy security concerns in addition to opening up market opportunities for Canadian clean energy technology developers and exporters. Canadian investments in M2M have supported public-private projects at upstream oil and natural gas facilities in China and Mexico that have facilitated the development of effective strategies to reduce fugitive emissions, decrease greenhouse gas externalities and improve energy efficiency. Canada is also involved in projects for landfill gas collection and flaring systems, as well as agricultural activities that support the use of bio-digesters on pig and dairy farms coupled with bio-filtration through composting.

#### 7.3.1.14 RETScreen

The RETScreen Clean Energy Project Analysis Software is a decision-support and capacity-building tool developed by the Government of Canada that allows users worldwide to evaluate various feasibility factors associated with renewable energy and energy efficiency project development (e.g. cost, emission reductions, financial viability etc). Available on the internet in 22 languages, the RETScreen tool has facilitated over 1000 MW of energy projects outside Canada, including hydro projects in Brazil, the Czech Republic, Guatemala, and Nicaragua, as well as photovoltaic projects in Costa Rica, Mauritania, and Senegal.

More than 40 new workshops for renewable energy, energy efficiency and cogeneration have been scheduled across Canada and around the world recently, in locations ranging from Calgary, Canada, to Manila, the Philippines and from Thurles, Ireland to Brazzaville, Republic of Congo. In addition, a RETScreen Clean Energy Project Analysis Course has been created for use by educational centres and training organisations around the globe. 166 colleges and universities worldwide now use RETScreen for training and more than 25,000 people visit the RETScreen website each week to access this information.

#### 7.3.1.15 Carbon Capture and Storage

Canada is investing heavily in research, development, and demonstration of carbon capture and storage (CCS) technologies. In recent years, Canada's federal and provincial governments have committed a total of approximately $3 billion in funding for CCS, which could lead to as many as five or six large-scale demonstration projects in Canada. This funding is provided through a number of federal and provincial programs such as the Government of Canada's recently created Clean Energy Fund. Canada's ecoENERGY Technology Initiative also provides funding of $151 million for seven CCS projects in a wide-range of sectors. The Government of Alberta is also contributing $2 billion toward large-scale CCS projects. Canada has been a global leader in CCS technology, including as host to the IEA GHG Weyburn-Midale $CO_2$ Monitoring and Storage Project, one of the world's first and largest CCS demonstration efforts. Canada is also an active member of the Carbon Sequestration Leadership Forum (CSLF), an international climate change initiative focused on the development of improved cost-effective CCS technologies, including for transport and long-term safe storage. In November 2007, Canada hosted one of three workshops that resulted in the development of key recommendations to the G8 to advance the development and deployment of CCS technologies. Canada's work on CCS continues in partnership between the IEA and CSLF to advance global implementation of these recommendations. The IEA will report back on progress in in 2010, when Canada hosts the G8 Summit. Furthermore, Canada has recently joined the new Global Carbon Capture and Storage Institute (GCCSI) which will also aim to accelerate implementation of CCS demonstration projects.

#### 7.3.1.16 Engineers Canada

Engineers Canada, through its Public Infrastructure Engineering Vulnerability Committee and in partnership with the federal government (NRCan), developed an engineering protocol to assess the vulnerability of infrastructure to climate change from an engineering perspective. Working both through the World Federation of Engineering Organizations and by making presentations at various international fora, Engineers Canada is working on making the protocol available to infrastructure owners and operators in other countries to assist in assessing their vulnerabilities to climate change.

#### 7.3.1.17 Carbon Budget Model (CBM-CFS3)

In 2002, the carbon accounting team of the Canadian Forest Sector (CFS-CAT) and the Canadian Model Forest Network (CMFN) developed a carbon accounting tool to help forest managers meet criteria and indicator reporting requirements for sustainable forest management and certification. The tool helps managers understand how their actions affect the net carbon balance of their forest estate. The CBM-CFS3 is a stand- and landscape-level modeling framework that simulates the dynamics of all forest carbon stocks required under the UNFCCC. It is compliant with the Good Practice Guidance for Land use, Land-use Change and Forestry (2003) report published by the IPCC.

Canada makes the accounting tool available at no charge, has undertaken numerous projects with forest management agencies in other countries, and has run training workshops for forest managers from Russia, Madagascar, Uganda, Thailand, Philippines, Mexico, China, and Korea and others. Over 500 people in 42 countries have obtained the software to date, and it is being used by individuals around the world.

In 2005, NRCan began a bilateral project with the Russian Federal Forest Agency to share knowledge and approaches to forest carbon accounting with scientists in Russia where the model has been used for regional- and national-scale analyses. More recently, the CFS-CAT has worked with the ComisiÚn Nacional Forestal, Mexico's Ministry of Forests and with forest managers in Spain, China, Italy and Korea.

#### 7.3.1.18 Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD)

Since the project's inception in 1999, Canada has provided one-third of the GOFC-GOLD Implementation Project's annual $900,000 budget. GOFC-GOLD is a coordinated international effort to ensure a systematic long-term program of space-based and on-the-ground observations of land cover and forest change, including the role of fire. It is designed to help provide the data needed for global monitoring of terrestrial resources, study of global change, and improved natural resources management. As a panel of the Global Terrestrial Observing System (GTOS), GOFC-GOLD interacts with several United Nations bodies and numerous international and national scientific and technical organizations. It develops contributory products at regional and global scales in two thematic areas. Land Cover Characteristics and Change; and Fire Monitoring and Mapping. A new biomass mapping theme is being developed. Among other uses, it is designed to help provide information needs under the UNFCCC, including methods and procedures for monitoring, measuring and reporting on reducing greenhouse gas emissions from deforestation and degradation in developing countries.

The Canadian Forest Service hosts the GOFC-GOLD Project Office. During the 2006-2009 period the Project office sponsored or co-sponsored 92 GOFC-GOLD events including technical seminars, workshops, missions, meetings and training courses held internationally and in Canada. In addition, initiative produced and released 40 documents during the reporting period.

Example projects undertaken during the reporting period included:

- Technical support to the Chinese State Forest Administration in developing the Asia-Pacific Forest Monitoring Network.
- Collaboration with the Canadian Space Agency (CSA) to improve global monitoring of reducing emissions from deforestation and forestation (REDD).
- Coordination of data acquisition for the radar data to be provided by several space agencies (CSA, ESA, JAXA, etc.).
- Support to the CFS Carbon Accounting team's collaboration with Mexico to transfer the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3).
- Collaboration international REDD organizations including the Prince's Rainforest Project, Google Foundation, UN-REDD Programme and Clinton Foundation.
- Sourcebook of measurement and monitoring methodologies for REDD:
- Central Africa Regional GOFC-GOLD network: OSFAC (Observatoire Satellital des ForŘts d'Afrique Centrale, http://osfac.umd.edu/index.htm) works to improve the quality and availability of satellite observations of forest and land cover in the Congo Basin and to produce useful and timely information products for a wide variety of users.
- Africa Pilot of the GOFC-GOLD Regional Network Data Initiative.

### 7.3.2 Bilateral Technology engagement

Canada engages bilaterally with both developed and developing country partners. Efforts with other developed

| | 2005/06 | 2006/07 | 2007/08 | 2008/09 |
|---|---|---|---|---|
| | CAD$ Million | | | |
| World Bank | 375.42 | | 392.55 | 392.55 |
| International Finance Corporation | 10.68 | | 6.08 | 6.08 |
| African Development Bank | 92.85 | 88.85 | 1.50 | 90.35 |
| Asian Development Bank | 73.27 | 95.77 | 29.40 | 125.17 |
| European Bank for Reconstruction and Development | 3.04 | | 4.99 | 4.99 |
| Inter-American Development Bank | 3.12 | | 21.48 | 21.48 |
| UNDP | 130.89 | | 100.50 | 100.50 |
| UNEP | 1.60 | 1.45 | | 1.45 |
| UNFCCC | 0.75 | | | |

Table 7.4: Financial contributions to multilateral institutions and programmes

countries tend to focus on the early stages of the technology continuum, taking the form of collaborative research, development, and demonstration of new technologies. Work with developing countries leans towards the later stages of the technology cycle, usually in the form of efforts to share knowledge and foster enabling environments in order to transfer technologies.

The Government of Canada has taken steps to assist developing countries directly with their technology needs. For example, CIDA has undertaken bilateral activities which have included technology transfer projects for climate change development with a capacity-building approach to help developing countries reduce their emissions of greenhouse gases and contribute to sustainable development. While much success has been achieved through these bilateral projects, key challenges remain with respect to supporting technology development in developing countries. These included the need to develop long-term approaches to support technology activities and the need for greater attention to the appropriateness of technology selection, with input from developing countries themselves.

Canada also makes use of other bilateral avenues to advance international collaboration. Canada has signed bilateral S&T agreements with several partner countries, including China, the EU, France, Germany, India, Israel, Japan, and Korea. These agreements serve as the guidelines for business and government to effectively work with partner countries to increase international science and technology capacity.

Canada works with the U.S. Department of Energy on a range of issues including oil sands technology, fuel cell technology, and solar energy, and has ongoing projects with American universities, research centres, and laboratories.

The Canada – US Clean Energy Dialogue (CED), is the most significant development in continental, environmental and energy policy since the North American Free Trade Agreement. The Clean Energy Dialogue focuses on three critical areas: expanding clean energy research and development; developing and deploying clean energy technology, especially carbon capture and storage; and, building a more efficient electricity grid based on clean and renewable generation.

# Chapter 8

# Research and Systematic Observation of Climate Change

## 8.1 Introduction

Climate system research and observations are essential for improving our understanding of the how the global climate system works, how both natural forces and human activities may cause it to change, and how these changes are likely to affect global ecosystems and human society. Such improved understanding, in turn, better equips the governments and people of Canada and of all other nations around the world to make informed choices regarding the rate and magnitude of future greenhouse gas and aerosol emission reductions and the strategies for adapting to the inevitable impacts of climate change.

Since the preparation of the Canada's Fourth National Communication on Climate Change in 2006, significant developments have taken place relating to such research and observations within Canada. These developments have built on initiatives and programs introduced previously. This chapter begins with an overview of these activities and then reports on the related progress in the nation's research and observation activities, highlighting some results from recent initiatives. Research related to climate change impacts and adaptation is discussed in Chapter 6 of this report.

## 8.2 Funding And Priority Setting

### 8.2.1 Partners and Priorities

Within Canada, the federal government provides most of the essential infrastructure for climate system research and long-term observations programs. It also employs research scientists and technicians to help provide the climate-related scientific services needed to serve the near-term as well as long-term well-being of Canadians, both directly and through sound advice to policy makers. The government research and observation activities are complemented by those within the Canadian academic community, which has a stronger focus on enquiry driven science. Productive partnerships have been established between the two communities and both continue to make substantial contributions to Canadian and international programs. The key Government of Canada (GoC) agencies involved in climate change-related sciences are Environment Canada, Fisheries and Oceans Canada (DFO), Natural Resources Canada (NRCan), and Agriculture and Agri-Food Canada (AAFC). Other federal departments, including Health Canada and Industry Canada, also contribute to the national knowledge base on climate change.

Responsibilities for climate system science among the key federal departments can be summarized as follows:

- Environment Canada has the lead responsibility for systematic observation and analysis of atmospheric, snow, sea/lake ice and hydrologic conditions, and for the development and updating of the national inventory for greenhouse gas sources and sinks, including those related to the management of forest and agricultural ecosystems. It also maintains substantive research programs in atmospheric-terrestrial climate system processes, in global climate system modelling, and in assessing the physical impacts of climate change on and vulnerability of freshwater and terrestrial ecosystems. Agencies within Environment Canada involved in these activities include the Climate Research Division, the Canadian Centre for Climate Modelling and Analysis, the National Water Research Institute, the Canadian Wildlife Service and the Canadian Ice Service, and the Adaptation and Impacts Research Division. Much of the activities undertaken by the latter are reported in Chapter 6.

- Fisheries and Oceans Canada (DFO) has the lead on marine science and contributes to climate change science through ocean monitoring and analysis, research on climate system processes and modelling (focusing on the ocean's role in the climate system), and sensitivities and impacts research on marine conditions and ecosystems. DFO's climate science programs are coordinated by the Oceanography and Climate Branch and are carried out in the department's five major oceanographic institutes in British Columbia, Manitoba, Quebec, Nova Scotia and Newfoundland.

- Natural Resources Canada (NRCan) has the lead responsibility for monitoring and analysis of permafrost and glaciers; investigating the relationship between forests and climate change (including the role of forests as sources and sinks for greenhouse gases), and undertaking the analysis of past climates through proxy data sources such as ice cores and tree rings. NRCan agencies involved in these activities include the Canadian Forest Service, the Canadian Centre for Remote Sensing and the Geological Survey of Canada. NRCan also houses the Climate Change Impacts and Adaptation Program (CCIAP), which is described in chapter 6.

- Agriculture and Agri-Food Canada (AAFC) – conducts research on understanding and quantifying the sources and sinks of GHGs in the agricultural sector, identifying promising management practices that reduce net GHG emissions, and on the verification of removals and emissions of GHGs from this sector for GHG accounting purposes

Priorities for climate change research in Canada are determined largely by consultative processes between the above federal government departments and academia, with some input from industry and other stakeholder groups. These consultations have led to new funding initiatives and coordinated programs that, together with the continuing core programs within the federal government departments, have significantly contributed to the systematic observations of the climate system and helped improve the scientific understanding of climate change since the Fourth National Communication on Climate Change. The following section discusses the key programs involved.

## 8.2.2 Major Funding and Coordination Programs

### 8.2.2.1 Targeted Initiatives for GoC Departments

#### Climate Change Interim Scenario (CCIS) (2005-2007)

This initiative provided $10 million of interim funding over two years for climate change science programs within Environment Canada to bridge the funding gap between the conclusion of AP2000 (an earlier funding initiative to address gaps in systematic observations, particularly in the North, and enhance carbon cycle and climate system research programs) in March 2005 and the implementation of the Clean Air Agenda.

#### Clean Air Agenda (CAA) (2007-2011)

In March 2007, the GoC implemented the Clean Air Agenda for Canada. One major component of the CAA was a climate change research program under the theme of Adaptation. This component allocated $86M over four years for related initiatives within Environment Canada, Natural Resources Canada, Indian and Northern Affairs Canada, Health Canada and Public Health Agency of Canada. Most of these initiatives focused on climate change impacts and adaptation research, which is discussed in greater detail in Chapter 6. However, $15 million of the adaptation component was allocated to climate system scientific research aimed at better understand the risks of climate change to Canadians. Of this, $7.3 million was targeted at research to improve the quality of Canadian global and regional climate model projections of future climate, with a focus on weather extremes. Another $1.9 million was assigned to initiatives to better transform the model outputs into detailed climate change scenarios for use in regional scale impacts and adaptation research. The remaining $5.8 million was to be used for research into the vulnerability of Canada's built infrastructure to weather and climate extremes.

#### International Polar Year (2007-2008)

International Polar Year (IPY) was a large, international research campaign comprising 160 endorsed scientific projects from 60 countries. During this campaign, IPY researchers devoted two years to observing new phenomena in the Earth's polar regions, developing innovative research tools and methodologies, and laying the foundation for advances in our scientific understanding of these regions and their role in the global system.

As part of its commitment to IPY, the Government of Canada provided $156M in new funding over five years (2006-2011) to implement an innovative Arctic program for scientific research, data collection and management, northern training and capacity building and public education opportunities. The research component, which spanned the 2007-2008 period, focused on two of Canada's most important scientific challenges for its northern regions - climate change impacts and adaptation, and the health and well being of northern communities. It involved 50 IPY projects, 1400 Canadian researchers, approximately 500 northern residents and 700 students and 190 international collaborators.

Partnerships have been critical to the success of IPY. Canadian participants included six federal government departments (Indian and Northern Affairs Canada, Environment Canada, Natural Resources Canada, Department of Fisheries and Oceans, Indus-

try Canada and Health Canada), Natural Sciences and Engineering Research Council of Canada (NSERC), territorial and provincial governments, northern communities, aboriginal organizations, universities, northern research institutes and colleges. Numerous international networks were also involved.

Legacies of IPY, both planned and unplanned, are likely to include improved and sustained observing systems, a wealth of new northern data, an improved northern data management system, strengthened international research collaboration, managing the data created by IPY and other northern research and a new generation of enthusiastic polar researchers. It will also have raised public awareness and discussion of polar issues, including sharing the benefits and knowledge with northern indigenous communities.

#### Program of Energy Research and Development (PERD)

PERD is managed by NRCan and involves the participation of 12 federal departments. For many years, a subcomponent of its overall program was focused on GHG sinks research, funded at about $2 million annually. PERD funding in GHG sinks supported targeted research by federal departments in the areas of forest sinks, agricultural sinks, ocean sinks, and hydroelectric reservoir fluxes. The ultimate aim was to help develop the accounting tools needed for accurate and verifiable reporting of carbon sinks under the Kyoto Protocol. PERD involvement with this activity ended in 2007.

There are also other PERD-funded research activities that have relevance to net greenhouse gas fluxes from ecosystems. These include funding of research in bioenergy and mitigation options, and are discussed elsewhere in this report.

### 8.2.2.2 Support for Academic Research

#### Canadian Foundation for Climate and Atmospheric Science (CFCAS) (2000-2011)

The CFCAS was established in 2000 with $60 million in funding from the GoC over six years. In 2003, this funding was extended to 2011 and increased by an additional $50 million. With a total budget of $110 million allocated for 2000 to 2011, CFCAS quickly became the main funding body in Canada for university-based research on climate and atmospheric sciences, and related oceanic work. It also supports research in air quality and extreme weather, both of which are areas of study closely linked to that of climate change. By June 2009, CFCAS resources for the remainder of the funding period had been fully allocated to multi-year university-based research, including the development of 24 major collaborative networks and 160 research projects. Over $54 million of CFCAS funds have been channelled by grantees to research personnel, thereby contributing to the development of skilled human resources. It has invested a quarter of its budget into Arctic and cryospheric conditions, as well as substantial amounts into research on drought, cold climate hydrology and related water issues.

CFCAS grants have attracted $144 million in matching support in cash or in kind from universities, federal research laboratories, and the private sector – effectively doubling the impact of the Foundation's investment. Of the 24 research networks, 15 are directly related to climate science. Several of the CFCAS-supported networks have been linked to international research programs, including SOLAS and CLIVAR; all involve multiple partners and collaborations with federal, provincial or private sector associates. Several of these have effectively replaced the former Climate Research Network in Canada (described in the Third National Communication).

The Foundation is an autonomous agency; its grants have been awarded on the basis of peer-reviewed competition. Grants support research in areas of national priority and relevance to policy development. Following its second federal endowment in 2003, CFCAS revised its funding strategy to better guide future investments towards higher impact research in emerging scientific issues, to filling gaps in research, and to addressing policy needs. As a result of this process, it shifted the majority of its funds (about 75%) toward major interdisciplinary and inter-sectoral initiatives, although individual projects continued to be supported to ensure the development of critical mass in these new areas, to support ongoing work in targeted areas and the development of highly qualified research personnel. CFCAS also identified four major themes toward which future investments would be targeted:

- Arctic, northern and cryospheric science;
- high-impact weather, including drought;
- physical impacts of climate change; and,
- use of analytical methods for monitoring and predicting of atmospheric and oceanic conditions.

The Foundation has also provided support for international offices, including (2004-2010) the International Project Office for SPARC (Stratospheric Processes and their Role in Climate), which moved to Canada in 2004; Working Group II of the Surface Ocean-Lower Atmosphere Study, which was co-located with the Canadian SOLAS office (2004-06); and for

the Canadian National Office for International Polar Year (2004-06). CFCAS provides the Canadian National Committee for WCRP (2007-present). It also provides the Chair and Secretariat for the International Group of Funding Agencies for Global Change Research (IGFA) – 2006-present.

CFCAS-funded climate science networks operating over the 2001-2005 period included:

- Climate Variability: Its Causes and Predictability (CLIVAR) (co-sponsored with NSERC);
- Fluxnet-Canada (co-sponsored with NSERC and BIOCAP Canada);
- Canadian Surface Ocean Lower Atmosphere Study (Canadian SOLAS) (co-sponsored with NSERC);
- Development of a Canadian Global Coupled Carbon Climate Model (GC3M);
- Modelling of Clouds and Climate Network (MOC2);
- Modelling of Global Chemistry for Climate;
- Canadian Regional Climate Modelling Network;
- Multiscale Air Quality Modelling Network;
- Quantitative Precipitation Forecasts;
- Enhanced Nowcasting of Extreme Weather.

With the five year mandate for the above networks completed in 2005, CFCAS funded additional research networks operating over the 2005-2010 period, some of which are sequels to the above networks operating between 2001 and 2005. The new networks include:

- Canadian Carbon Program;
- Canadian Regional Climate Modelling and Diagnostics
- Storm Studies in the Arctic (STAR);
- Western Canadian Cryospheric Network;
- Polar Climate Stability Network;
- Canadian Network for the Detection of Atmospheric Change (CANDAC), at the Polar Environment Atmospheric Research Laboratory (PEARL);
- Drought Research Initiative (DRI);
- Cloud–Aerosol Feedbacks and Climate (CAFC);
- Improved Processes and Parameterisation for Prediction in Cold Regions;
- The Canadian SPARC (Stratospheric Processes and Their Role in Climate) Program;
- Environmental Prediction for Canadian Cities;
- Interdisciplinary Marine Environmental Prediction in the Atlantic Coastal Region
- Prediction and Predictability of the Global Atmosphere-Ocean System from Days to Decades.

### Natural Sciences and Engineering Research Council (NSERC)

The core role of NSERC is to support university research and training in the fields of science and engineering. NSERC fulfils its mission by awarding scholarships and research grants through peer-reviewed competition, and by building partnerships among universities, colleges, governments and the private sector. Between 2006-07 and 2008-09, NSERC had an operating budget of $2.95 billion that was spent on grant support, research and administrative activities. A breakdown of annual funding indicates that in 2008-2009, NSERC invested $982 million in university-based research and training in all the natural sciences and engineering. This included a base budget of $729 million and an additional $253 million that flowed through NSERC for programs such as the Canada Research Chairs, Canada Graduate Scholarships and the Networks of Centres of Excellence (NCE).

In the fiscal year 2008-2009, NSERC funded the following climate change related research areas: $28.6 million for Arctic Climate Change Monitoring and Adaptation, $17.5 million for Climate and Atmospheric Science, and Meteorology, $11.0 million in the area of Air Pollution: Measurement, Treatment and Remediation, $4.8 million in support of Energy Efficiency and Cleaner Methods of Extracting, Processing, and Using Hydrocarbon Fuels, and $22.8 million in clean energy and alternative energy sources such as wind, solar, fuel cells, biofuels and hydrogen.Together these investments supported the work of more than 1,000 professors at some 60 institutions.

The above NSERC also provides crucial financial support and co-sponsorship to a number of climate related research networks, including:

- ArcticNet
- Fluxnet-Canada
- Canadian Carbon Program

- Canadian Arctic Shelf Exchange Study (CASES);
- Mackenzie GEWEX Study (MAGS).
- Canadian Surface Ocean Lower Atmosphere Study (C-SOLAS)

#### ArcticNet (2003-2011)

ArcticNet became a fully operational Network of Centres of Excellence (NCE) in the area of Natural Resources and the Environment in 2003. The NCE program has been in place since 1989 and is an integral part of the federal government's Innovation Strategy, connecting nation-wide, multidisciplinary and multisectoral research partnerships with industrial expertise and strategic investment. The NCE initiative is supported by four Canadian federal granting agencies – the Canadian Institutes of Health Research (CIHR), NSERC, SSHRC, and Industry Canada.

ArcticNet researchers study the impacts of climate change in the coastal Canadian Arctic by partnering scientists and managers in the natural, human health and social sciences with Inuit organizations, northern communities, federal and provincial agencies and the private sector. The central objective of ArcticNet is to develop and disseminate the knowledge to formulate adaptation strategies and national policies to face the impacts and opportunities of climate change and globalization in the Arctic.

The Network is built around a newly granted research icebreaker CCGS Amundsen that has become instrumental in solving the lack of observational data in the coastal Arctic. Phase 1 of ArcticNet's research program (2004-2008) comprised 26 research projects, structured into four Integrated Regional Impact Studies (IRISs) of coastal communities and ecosystems. The Network was organized into the four research themes:

- Climate Change Impacts in the Canadian High Arctic: a Comparative Study Along the East-West Gradient in Physical and Societal Conditions
- Food, Water and Resources in the Shifting N-S Thermal Gradient of the Terrestrial Eastern Canadian Arctic
- Managing the Largest Canadian Watershed in a New Climate: Land-ocean Interactions in Sub-Arctic Hudson Bay
- Adapting to Change in the Canadian Arctic: Knowledge Transfer, Policies & Strategies

In 2007, ArcticNet secured $19M in additional GoC funding to complete its first seven–year funding cycle, which is due to end in 2011. In 2008, 27 new projects were selected to form the core research program until 2011. Arctic Net is now funding 110 researchers. The Phase II research program continues the multidisciplinary approach including the monitoring and modelling of climate indicators, infrastructure destabilization, marine and terrestrial ecosystems, geopolitics, and the impacts of climate change on culture and health.

CCGS Amundsen Expedition (2007-2008). In 2008, the Canadian icebreaker Amundsen completed an historic 15-month expedition to the Canadian Arctic to support ArcticNet and International Polar Year projects. One key project was the Circumpolar Flaw Lead study, a $20M international effort led by Canada to understand the role of the leads in the context of Arctic warming. In 2009 the Amundsen is in the Arctic again, supporting several Canadian and international research projects.

### 8.2.2.3 Canadian Space Agency Program

The Canadian Space Agency (CSA) is funded by the Government of Canada. CSA contributes to environmental monitoring and science for Canada and the world by developing and using technologies that provide space-borne observations and information about the current state and evolution of the climate, the quality of the air and the water as well as the biodiversity of the country and the planet. Space-based observations are particularly useful for monitoring changes in the physical, chemical and biological aspects of the Earth and for supporting climate research because of global nature of the climate system. However, the geographic characteristics of Canada also necessitate observing tools that are specific to its territory. Earth observation satellites are a practical method of achieving these objectives within reasonable costs.

CSA contributions to climate system observations and research during 2006-2009, discussed in the relevant sections of this report, included:

- operation of Canadian satellite missions and scientific instruments to ensure provision of Earth Observation data to the users;
- contribution of expertise and instruments to international science mission; and
- funding of research by GoC departments, industry and universities to improve utilization and develop new applications of existing Canadian (e.g. RADARSAT, SCISAT) and International (e.g. Cloudsat) space assets for climate change purposes.

#### 8.2.2.4 Provincial and Territorial Initiatives

**Quebec**

Since 2000, the Government of Quebec has made major efforts in regard to climate and the adaptation to climate change by creating Ouranos, the research consortium on regional climatology and adaptation to climate change. Quebec has recently renewed its basic funding until 2014, on the order of $4 million per year. Additional funding of $10 million has also been allocated to Ouranos until 2013 in order to carry out specific projects on climate change adaptation.

#### 8.2.2.5 Additional support for Academic Research at the provincial and territorial level

**Quebec:** In Quebec, the Fonds québécois de la recherche sur la nature et les technologies (FQRNT), contributes to climate change research, particularly by fostering the creation of a network of researchers through its Strategic Clusters program.

Quebec's key players in the area of climate change are the Ouranos Consortium on regional climatology and adaptation to climate change, and the Canadian Regional Climate Modelling and Diagnostics (CRCM) Network, based at Université du Québec à Montréal (UQAM). Quebec also boasts many research and interuniversity clusters, including:

- the Global Environmental and Climate Change Centre (GEC3), based at McGill University;
- the Centre d'études nordiques (CEN), based at Université Laval;
- Québec-Océan, the Interinstitutional Oceanographers Research Group of Quebec, based at Université Laval; and
- the Geochemistry and Geodynamics Research Centre (GEOTOP), based at UQAM.

All are made up of researchers from different Quebec universities.

## 8.3 Systematic Observation

### 8.3.1 Overview

Systematic observations of the climate system are essential for understanding the mean states of its various components over time and their natural variability around these means, for detecting any change in these means, and for attributing these changes to specific causes. Furthermore, observations can also help clarify the dynamics of the processes by which the various components of the climate system interact and the sensitivity of these processes to forces of change. Such process research in turn allows modellers to incorporate them into climate system models through mathematical equations, thus making the prediction of seasonal or inter-annual changes and the long-term projections of future climates possible. Such projections are the foundation for sound policy decisions with respect to mitigating the risks of climate change through emission reductions and adaptation strategies.

The climate system involves five major components: the atmosphere, oceans, the cryosphere (floating ice, snow, permafrost and glaciers), the hydrosphere, and a terrestrial component (including vegetation and soils). As in other countries, the systematic collection, quality assurance, archiving and dissemination of climate system data in Canada involves many agencies and institutions, and arise out of a broad spectrum of requirements, applications and obligations. The constitutional division of responsibilities between different levels of government, however, means that no single jurisdiction has responsibility for all components of the climate system. This reality is reflected in the varying degrees to which observational networks and systems are managed and coordinated across the country. The lead role of the GoC in developing coherent, long-established systems for atmospheric and oceanic observations is relatively unambiguous (although existing ocean observing programs are limited in scope and have historically not been designed or resourced as a climate observing system). Since the atmosphere and oceans are common to many other countries, the GoC also has commitments under international programs and agreements to do so to international standards. In contrast, provincial/territorial jurisdiction is generally paramount where terrestrial systems (e.g. forests, agricultural lands, wetlands and freshwater bodies) are concerned. As a result, observations of the terrestrial component of the climate system across the country are less consistent and not as well coordinated.

Environment Canada maintains a national network of climate observing stations extending from coast to coast and into Canada's North. Data gathered at these stations include observations of atmospheric variables, lake and river conditions, ice cover, and snow cover. Background atmospheric concentrations of greenhouse gases are also measured at some of these. The networks adhere to standards set by the World Meteorological Organization and contribute to global observation networks such as the Global Climate Observing System (GCOS). DFO has responsibility for the collection and management of key physical, chemical

and biological variables describing the oceans that surround Canada, including the Northeast Pacific, the Arctic and the Northwest Atlantic. DFO leads national co-ordination of the Global Ocean Observing System (GOOS) in collaboration with other relevant GoC departments. NRCan maintains networks and data archives on permafrost and glaciers. Both of these national networks are linked to Global Terrestrial Networks for Permafrost and Glaciers (GTN-P and GTN-G). These networks are described in brief in the section below. Related activities have also been summarized in The Canadian National Report on Systematic Observations for Climate - National Activities with Respect to the Global Climate Observing System (GCOS) Implementation Plan, which was submitted to the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) in 2008. Finally, the Canadian Space Agency works closely with Canadian scientists in development space based missions to support of climate system research. These are discussed in greater detail in section 8.3.

Canada is also a significant contributor to the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), and the Global Terrestrial Observing System (GTOS). Contributions include systematic observations, measurements, derived products and data management related to essential Climate Variables (ECVs), technical and scientific expertise, and to a lesser extent, financial support. The key federal science departments participating in these programs include Environment Canada (EC), Fisheries and Oceans Canada (DFO), Natural Resources Canada (NRCan), and Agriculture and Agri-food Canada (AAFC). The Canadian Space Agency (CSA) supports these federal science departments in a wide variety of space-related activities and applications development, including coordination of all aspects of the Canadian Space Program.

Canada is firmly committed to the Group on Earth Observations (GEO), which seeks to coordinate international efforts to build a Global Earth Observation System of Systems (GEOSS). The Canadian GEO, established in 2005, has identified several specific national priorities for such observations, including: soil moisture monitoring, modelling and forecasts; integrated planning of monitoring networks and environmental data /products access; and sustained arctic monitoring programs. GCOS contributes the climate component to the GEOSS. Environment Canada's Meteorological Service of Canada (MSC) is responsible for national coordination of GCOS. Experiences gained during the compilation of this national GCOS report affirm the need to re-establish a national coordinating mechanism among participating federal departments and agencies for GCOS related national planning purposes. Canada is also a participant in the international Sustaining Arctic Observing Networks initiative.

Canada participates in both the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM), a formal body of the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC). Canada also participates in the Data Buoy Cooperation Panel (DBCP) of the Ship Observations Team (SOT). The DBCP is charged with coordinating at the international level, the drifting and moored buoy programs. Within the Canadian framework, DFO has developed ocean monitoring programs for both the Atlantic and Pacific coastal and ocean regions and to a lesser but increasing extent for the Arctic.

## 8.3.2 Monitoring Networks

### 8.3.2.1 Atmosphere

Weather and climate. Environment Canada's national ground-based weather, climate, upper air and meteorological marine observation networks are well established and follow well-defined operating standards and procedures. Most of these networks adhere to GCOS climate monitoring principles. Network spatial densities and station distributions are relatively stable, with lower densities in the sparsely populated northern regions. The Surface Weather (SWX) Network involves about 700 fully automated stations, many of which are located at airports or in urban settings. A large number also do not have long records, or have undergone physical changes over time. Hence, only a sub-set are suitable for systematic climate observations. Canada also contributes to the international Voluntary Observing Ship Climate Project (VOSClim) through its Automated Volunteer Observing Ships (AVOS). Plans call for additional installations to focus on vessels plying data sparse waters, such as in the Canadian Arctic.

Within this broader atmospheric monitoring program, EC operates two surface networks directly related to climate change – the Canadian Reference Climate Stations Network and the daily Climatological Network. The Canadian Reference Climate Stations (RCS) network consists of 305 stations, of which 87 are included in the Global Surface Network (GSN). In addition to monitoring the GCOS Surface Essential Climate Variables (ECVs), the Canadian GSN stations also measure and report atmospheric pressure, wind speed and direction, humidity, and snow on ground on hourly and synoptic reporting frequencies. Some data coverage gaps remain in the Canadian GSN, specifically in extremely remote northern regions where it is expensive to install

and maintain autostations with little or no human presence. The larger RCS network is primarily intended for determining climate trends on regional and national scales. It was initially established in the early 1990s by identifying and designating stations with continuous high quality observations of thirty plus years in duration. The resulting network was a mixture of automated stations, human-based aviation weather observing sites, daily temperature and precipitation climatological stations operated by volunteers and co-operating agencies. Since about 2000, MSC has been converting about 10% of these stations per year to a standardized autostation configuration. However, in recent years this rate of modernization has fallen due to resource limitations. Approximately 60 ordinary climatological stations remain to be modernized. This automation process has also caused problems with the homogeneity of the climate data time series However, work is underway to improve the integration of new auto station data into homogeneous climate series.

Under the auspices of an MOU between Environment Canada and the American NOAA, MSC and the US National Climatic Data Center (NCDC) have entered into a bilateral agreement to coordinate standards, procedures, equipment and measurement programs between the Canadian RCS and the US Climate Reference Network (CRN) with the objective of establishing and maintaining a North American climate reference network. One example is the cooperative effort towards developing an operational snowfall measurement algorithm at the autostations where total precipitation weighing gauges are employed.

By comparison, the daily Climatological Network currently consists of approximately 750 sites where observations of temperature (minimum and maximum), precipitation (rainfall or snowfall) and snow depth are recorded once- or twice-daily. In the past, observations at most of these stations were reported in documents submitted to Environment Canada several weeks after the end of the month. Environment Canada has developed an internet-based data entry system to allow the observers to submit their observations in near real-time. Immediate automatic quality control and feedback alert the observer of any suspect entry. Another near real-time data entry system is based on digital touch-tone phone that also provides some limited quality control. Eventually, all data entry from this network will be through either of these near real-time electronic data entry modes. This modernization process provides more timely access and better quality of daily climate data from these stations.

#### GCOS and Full WWW/GOS Upper Air Networks.

Canada maintains 31 of the approximately 900 upper air radiosonde stations and 5 of the estimated 165 GCOS Upper Air Network (GUAN) stations operating under the global WWW/GOS program. The Canadian upper air stations are located at Alert, Goose Bay, Moosonee, Fort Smith and Cambridge Bay. The latter was formally designated as a GUAN site shortly after the release of the 2002 Canadian GCOS report.

At the radiosonde stations, balloon borne radiosondes are released twice daily to measure and simultaneously transmit data, including temperature, humidity and pressure to automated ground systems. Wind direction and speed are determined by using Loran-C and GPS technology to help track the radio signal transmitted by the radiosonde. All of the stations in the upper air network have recently been upgraded.

Upper air observations from the relatively low density Canadian upper air radiosonde network are supplemented through initiatives such as the Canadian Aircraft Meteorological Data Relay (AMDAR) program. About 35,000 observations of wind and temperature are generated daily by a fleet of about 100 aircraft operated by Air Canada Jazz. These observations translate into roughly 5,000 soundings per week from 54 Canadian airports from coast to coast mostly located south of 55 0N and from 14 USA airports. The quality of the data is monitored in near-real-time by the Canadian Meteorological Centre before the data are used in CMC's national data assimilation system and distributed internationally. The Canadian AMDAR data are distributed free of charge. Deploying an AMDAR capacity on regional airlines operating in northern Canada would be highly beneficial. However, due to technical difficulties, attempts to date have not been successful.

At the provincial level, the Government of Quebec operates a network of 336 climatological stations, consisting of 288 stations with twice daily observations transmitted by a data logger and 48 automated hourly stations meeting World Meteorological Organization (WMO) standards, for which data are often available for very long periods in the past. A technical team of seven people is responsible for validating the data to ensure their quality. A major network modernization is in progress to add automated hourly measurement equipment to all manual observation stations, as well as automated temperature measurements at ten stations in northern Quebec.

#### Atmospheric Composition.

The atmospheric composition measurement program operated by Environment Canada is largely focused on

collecting data for research purposes. However, those stations contributing ECVs to the GCOS via WMO's Global Atmospheric Watch have been or are in the process of being upgraded from project-based to long-term systematic measurement programs.

The Canadian greenhouse gas and aerosol measurement program uses the GCOS Implementation Plan (2004), along with guidelines provided by WMO, IGACO, WCRP and other programs to ensure that the data meets GAW/IGACO and other related international specifications. All eight sites are located in remote continental/regionally representative locations. In addition to the weekly flask network for greenhouse gases, in-situ hourly greenhouse gas data is now also collected at all eight sites. Aerosol mass, light scattering and absorption, and chemistry measurements have been enhanced at four of the sites. Carbon dioxide stable isotope measurements are made at five sites. There remains, however, a significant gap in the monitoring of atmospheric composition north of 60 degrees in Canada, and the network remains focused at understanding continental scale processes. The Alert Observatory is the only Canadian Arctic observatory making long-term measurements in the Arctic.

EC's GAW Observatory at Alert, Nunavut is also one of three WMO Global GHG inter-comparison sites, and includes C and O isotope measurements. EC is playing a lead role in developing the isotope calibration methodologies and protocols. Substantial progress is being made in establishing the suite of aerosol chemistry and physical properties measurements at Whistler (British Columbia), East Trout Lake (Saskatchewan) and the EC Centre for Atmospheric Research in Egbert (Ontario), as well as at Alert.

Most greenhouse gas and aerosol data are reported to the relevant WMO World Data Centers. The exception is C and O isotopes data, for which sampling protocols do not yet exist. Thus far, aerosol data are reported for the Alert GAW site only. The Canadian Climate Chemistry Baseline Network sites also provide the infrastructure for measurements and studies by national and international scientific partners.

Ground level ozone data is collected at stations that are part of the Canadian Air and Precipitation Monitoring Network (CAPMoN), a non-urban network where the measurement sites are selected to be regionally representative. With the help of data analysis/interpretation studies and climate chemistry models for C,N and S cycles, the data records now span sufficient years to provide representative ozone profiles for all seasons and atmospheric transport regimes. Parallel research pertaining to C sources and sinks, aerosol processes, ice core aerosol characterization and forest fire impacts are underway to improve historical and current quantification of natural and anthropogenic emissions.

As part of the WMO/GAW precision filter radiometer network, EC also measures aerosol optical depth at Bratt's Lake (Saskatchewan). In addition, EC collaborates with the university community in the operation of AEROCAN, a sunphotometer and sky-scanning radiometer network of 20 sites across Canada (ten of which operate in the real-time). The objective of AEROCAN is to acquire data at spatial-temporal scales sufficient to develop and validate a Canadian climatology for aerosol optical properties such as optical depth, size distribution and mass. A climatology of aerosol properties is, in turn, important in correcting remote sensing data for related biases. AEROCAN is part of the federated AERONET network, and the data collected at its sites are made available to the user community through the NASA AERONET website.

In Quebec, the City of Montreal and the Government of Quebec operate 75 ambient air quality stations that meet standards set by the National Air Pollutant Surveillance Network, a pan Canadian group of air quality surveillance network managers. All Quebec data produced go through a stringent validation process and the vast majority of the information is broadcast in real time via the Air Quality Index (http://www.mddep.gouv.qc.ca/air/iqa/index_en.htm) available on the Web sites of the City of Montreal Web and the Ministère du Développement durable, de l'Environnement et des Parcs. The index reaches nearly 95% of the Quebec population. The entire ambient air quality program is undergoing a complete modernization and most of its measurement tools will be upgraded by March 2013.

#### 8.3.2.2 Oceans

Canada's Ocean's Action Plan (OAP) articulates a vision and mission for Canadians focused on safe and accessible waterways, healthy and productive aquatic ecosystems, and sustainable fisheries and aquaculture. The OAP is based on the key principles of international leadership, sovereignty and security, integrated oceans management, health of the oceans and advancements in oceans science and technology. Ocean monitoring is a crucial requirement for achieving the goals of the OAP.

Fisheries and Oceans Canada (DFO) is responsible for undertaking this monitoring. It collects and manages data of physical, chemical and biological variables describing the climate of the oceans that surround Canada, including the Northeast Pacific, Northwest Atlantic, Hudson Bay, the Beaufort Sea, the Arctic Archipelago and the Labrador Sea. Observations are made by ship, by moored and floating buoys and by re-

mote sensing. The rescue of historical data has continued to be a significant initiative over the past few years. Collaborations are established with other government departments and agencies to include oceanographic activities for which the responsibility falls outside DFO.

### Pacific and Atlantic Ocean Monitoring

DFO research ships routinely monitor ocean conditions including vertical profiles of temperature, salinity, nutrients (i.e. N, P and Si) and biological (e.g. phytoplankton and zooplankton) data. The Atlantic Zone Monitoring Program (AZMP) includes a network of six stations sampled bi-weekly, 13 seasonal cross-shelf sections sampled one to two times annually, and fisheries resource surveys (2,000 stations sampled annually) covering the NW Atlantic continental shelf from 42-56 degrees north. A section across the Labrador Sea (referred to as AR7W) is sampled annually for temperature, salinity, oxygen, nutrients, carbon system variables, chlorofluorocarbons, and microbial, phytoplankton and zooplankton abundance and production. It is an important ocean monitoring program for climate research, because each year it samples the water masses that contribute to the Atlantic branch of the ocean's thermohaline circulation. Since 2006, a few stations have been added to the offshore end of the AZMP Halifax section to provide annual downstream sampling of these same variables (across the Slope Water and the Deep Western Boundary Current). Similarly, the Pacific Line P (Vancouver Island to 50°N, 145°W), which is surveyed three times per year for temperature, salinity, oxygen, carbon dioxide, chlorophyll, nutrients and zooplankton, is a cornerstone of long-term observations of the effects of climate variability and change on ocean ecosystems.

Satellite data images are captured by DFO at receiving stations at the Bedford Institute of Oceanography – Atlantic Region and the Institute of Ocean Sciences – Pacific Coast. Sea-surface temperatures images are derived from AVHRR on the NOAA series of polar orbiting weather satellites and at Resolute Bay. Both the Pacific Coast and the Resolute datasets are transmitted to L'Institue Maurice Lamontagne (IML) for analysis. Chlorophyll concentration images are produced from SeaWifs data collected on the ORBView-2 satellites. Primary Production images are derived from the semi-monthly composites of chlorophyll concentration and temperature. On-line archives of imagery are available from both institutes.

DFO's Integrated Science Data Management Branch (ISDM) acquires, processes, archives and disseminates all real-time surface drifter data that are distributed on the Global Telecommunications System as well as delayed mode data acquired from other sources. The reports are processed to remove duplicates and quality control routines are applied to the reported measurements. As a designated Responsible National Oceanographic Data Centre (RNODC), DFO partners with the Atlantic Oceanographic and Meteorological Laboratory in the U.S. to provide long term archive facilities for the Global Drifter Center data. ECVs included are surface and subsurface water temperatures, air pressure and pressure tendency, surface and subsurface salinity, and surface currents.

Canada also continues to make a major contribution to the international Argo program, which now has over 3,000 profiling submersible floats in the world's oceans, and is providing unprecedented ongoing coverage of global ocean temperature and salinity variability. Argo (together with altimetry and other observations) will also provide a unique dataset for the development and testing of assimilative ocean circulation models, a modern temperature-salinity climatology for the global ocean, and time series of variability in heat and freshwater storage and transports which can be used for analysis of the dominant patterns and modes of coupled atmosphere-ocean variability. Canada's contribution to ARGO to date has included deployment of over 250 ocean floats, primarily in the northwest Atlantic and northeast Pacific Oceans.

### Arctic Observations

The Arctic climate programs are less sophisticated than in the Atlantic and Pacific, but include through-flow monitoring in key straits of ocean current through full depth, ice drift, temperature and salinity at the seabed and acoustic backscatter from zooplankton. In addition, there is monitoring of the pack ice in the Beaufort Sea by instruments on sub-sea moorings. The time series were 15 years long in April 2005. The instruments measure ice draft (related to thickness), ice ridges and leads, ice drift, ocean current through full depth, temperature and salinity at the seabed and acoustic backscatter from zooplankton.

### Sea Levels

DFO also has responsibility for monitoring sea level. In addition to the existing Atlantic and Pacific National Sea Level Network of coastal stations, DFO installed a coastal Arctic component during the period 2002-2005 to address critical gaps in the Global Sea Level Observing System (GLOSS) array. Five new northern sites were established at: Alert, Ellesmere Island; Qikiqtarjuaq, Baffin Island; Nain, Labrador; Tuktoyaktuk, Northwest Territories; and Holman, Victoria Island. All

five sites were operational by July 2004, thereby addressing a major gap in this component of the monitoring program. The Canadian Hydrographic Service is collecting data from the tide gauging stations on a daily basis.

#### Data Management

National coordination and integrity across the various DFO monitoring programs ensures common protocols for both observation and data archiving. The DFO Integrated Data Management Service (ISDM) manages and archives ocean data collected by DFO, or acquired through national and international programmes in ocean areas adjacent to Canada. ISDM also assembles, processes, quality controls, and distributes large volumes of climate related data, as a data centre for the major international climate research programs. Systematic observation of ecosystem state variables provides the data required to test scientific conjectures on the propagation of climate signals through linked components of the ocean's biota and physical environment.

### 8.3.2.3 Cryosphere

#### Sea Ice

EC's Canadian Ice Service (CIS) observes sea ice conditions on a daily basis in the ice-encumbered waters within and adjacent to Canada's exclusive economic zone, including the Great Lakes and Saint Lawrence River. Radarsat is the primary observing platform, with over 7,000 Synthetic Aperture Radar images from Radarsat and Radarsat 2 analyzed annually. The radar data are complemented by visual and infrared (IR) satellite images. Aircraft reconnaissance is also conducted in shipping areas to provide visual confirmation of satellite observations. Along the East Coast of Canada, these also provide iceberg surveillance.

The sea ice information gathered through these observations and analyses, in addition to improving the safety of navigation, provide invaluable data for climate studies. CIS produces charts of sea ice distribution on a weekly basis specifically for ice climate purposes. These data have been digitized back to 1968, when regular weekly charts were first produced, and are available freely on the CIS website. The weekly charts are also sent to the World Data Center for Glaciology (formerly named the World Data Center A for Glaciology (Snow and Ice), which is co-located with the US National Snow and Ice Data Center in Boulder, Colorado. These data were compiled into three climatic ice atlases for Northern Canada Waters, the East Coast of Canada and the Great Lakes in early 2000s. Updates are planned for 2010. Additional analysis of the data, in the form of climate variability and trend analysis, and current departure from normal, is also available on the CIS web site. A data rescue project to digitize additional sea ice cover charts as far back as 1959 has been completed and digitization of the historical Polar Continental Shelf Project ice charts will start soon.

CIS also produces daily charts of iceberg distribution along the East Coast of Canada. Meanwhile, DFO research programs including the monitoring of sea ice draft and drift with moored buoys, and the use of helicopter-borne sensors to collect sea ice thickness data for use joint research projects with CIS.

#### Lake and River Ice

Dates of freeze-up and break-up of ice cover on lakes and rivers are a useful indicator of climate change, being well correlated with air temperature during the transition seasons, and are an important ecological indicator. Identified GCOS requirements are for daily observations of ice conditions in spring and fall for selected large lakes and several hundred medium-sized lakes distributed across middle and high latitudes. There are also associated needs for the selection of a set of GCOS reference lakes for assessing long-term variability, development of methods for merging in-situ and remotely sensed information on this parameter, and for a central or several regional archive(s) of information.

Canada has contributed significantly to GCOS in this area. In-situ observations exist at several hundred Canadian lake and river sites for various periods, with some sites going back to the early 1800s. Though the in-situ network has declined significantly over the past 10 years, efforts are underway to reverse this trend. For example, a volunteer "Icewatch" program provides lake and river ice reports for about 85 locations across Canada. Thickness measurements are now also being recorded at some 65 weather stations across Canada. Satellite-based methods have also demonstrated excellent potential, and monitoring for large Arctic lakes has already been implemented using passive microwave observations. This record is being extended back in time using the available satellite record (1978-present). The Canadian Ice Service (CIS) began weekly monitoring of ice extent on small lakes in 1995, using NOAA AVHRR and RADARSAT imagery, in support of Canadian Meteorological Centre (CMC) needs for lake ice coverage in numerical weather models. The program started with 34 lakes, but has now been increased to approximately 130 lakes. Canadian researchers are currently working on an ESA-supported project to develop an operational method for mapping freeze-up and break-up dates over large areas of Canada using SAR (ASAR Global Moni-

toring Mode) and optical (AATSR) data from the ENVISAT satellite.

### Snow on Ground

Canada's national snow on ground (snow depth) in-situ measurement program involves a composite of automatic and staffed stations that are part of Environment Canada's RCS, surface weather, a volunteer climate observing network, and reports from contracted aviation service providers. While the total number of reporting sites has decreased significantly, largely due to reductions in the volunteer program, the number of stations reporting in real-time to near-real-time is increasing due to the introduction of electronic reporting from the volunteer network. Considerable effort is underway to improve measurement of snow depth and derivation of snowfall from autostations. EC's Canadian Meteorological Centre produces a daily global snow depth analysis based on real-time observations from synoptic and hourly meteorological reports. It plans to improve the resolution of the analysis in the near future. EC has also made considerable progress in developing passive microwave derived snow cover fraction and water equivalent (SWE) information over the sub-Arctic of North America. Natural Resource Canada's (NRCan) Canadian Centre for Remote Sensing (CCRS) has produced daily snow cover derived from NOAA AVHRR observations since 1982. A project has been started to assimilate satellite derived information on SWE with the Canadian Land Data Assimilation System. One of the current focuses of the Canadian IPY is the integration of modelling and remote sensing approaches for SWE retrieval in mountainous areas.

At the provincial and territorial level, the Government of Quebec operates a network of 103 snow gauge stations where snow thickness, water equivalent and density are measured. Data are often available for periods dating back more than 50 years.

### Permafrost

Permafrost monitoring is an important national priority for Canada; one third of the permafrost regions of the northern hemisphere lie within Canada and 50% of Canadian land mass is covered by the permafrost zone. Two key parameters are measured through in-situ observations: active layer and permafrost thermal state. At most thermal sites, ground temperatures are measured to a depth of 20 meters (although some boreholes are deeper). At the active layer sites, regular measurements are also taken of the depth of the soil layer above the permafrost that undergoes annual freeze-thaw cycle. The Fourth National Communication noted that there were some 75 thermal sites and 10 active layer sites in operation within the Canadian Permafrost Monitoring Network in 2005. However, there were extensive gaps in the network in place at the time, particularly in the southern portion of the discontinuous permafrost zone, in the Yukon Territory and in Nunavut, including the region to the west of Hudson Bay. Through new funding programs, this network has now been increased to approximately 150 active layer and/or thermal monitoring sites, with observation periods ranging from a few to over 20 years. Although NRCan's Geological Survey of Canada has the lead in this program, there is no dedicated long-term funding for the operation of these sites. Hence, their maintenance relies on short-term funding projects that involve many agencies and institutions. The November 2008 Canadian National Report on Systematic Observations for Climate provides details on the permafrost monitoring network and its progress against objectives of the GCOS implementation plan.

The expansion of the permafrost monitoring network occurred largely due to several regional project -based initiatives. Through the Northern Energy Development Memorandum to Cabinet (NED, 2004-2010), NRCan/GSC was allocated funding for the 2004-2010 period to add over 70 new thermal monitoring sites in the MacKenzie Basin region of north-western Canada, including the sensitive and dynamic environments of the Mackenzie Delta. Indian and Northern Affairs Canada (INAC), the hydrocarbon industry and local communities within the Mackenzie corridor were important partners in this expansion. Further funding was also obtained through the federal government's IPY program (2007-2011) for a collaborative "Thermal State of Permafrost" project led by NRCan/GSC, the University of Ottawa and Carleton University. This project is Canada's major permafrost contribution to IPY. One of the major achievements of this project was the establishment of new monitoring sites in the Yukon Territory, northern Manitoba and (in collaboration with the Government of Nunavut) in six communities in the Baffin Region. Additional support has subsequently been received from INAC for 2009-2010 to facilitate further site establishment in Nunavut and address gaps in the western portion of the Territory.

The more than 150 thermal sites and 10 active sites now included in the Canadian permafrost network contribute to the Global Terrestrial Network for Permafrost (GTN-P), established by the International Permafrost Association (IPA) under WMO/GCOS. NRCan/GSC continues to coordinate the GTN-P on behalf of the international community, and to maintain the website through which summary data and information are dis-

seminated. Currently, summary datasets from 18 long-term Canadian sites are posted on the website. There are, however, plans, through the IPY project, to post summary data for all long-term monitoring sites as well as those established over the last three years. A snapshot database of the thermal state of permafrost over the IPY period is currently being compiled with its release planned in spring 2010. All observational data are archived with the World Data Center for Glaciology as a contribution to the IPA's Global Geocryological Database. Data from active layer sites are also submitted on an annual basis to the Circumpolar Active Layer Monitoring Program (CALM) within the GTN-P and posted along with site metadata on the website hosted by the University of Delaware.

#### Glaciers

The monitoring and assessment of Canada's glaciers is a regional and national priority as they concern an important freshwater resource. Significant hydrological and ecosystems impacts are anticipated, and have already been observed in some areas, as a result of their decline. Their role in regulating flow to oceans is significant as it affects sea-level rise and the variability of marine ice formation. Development in resource-rich regions where glaciers are also found requires information on glacier fluctuations and their influence on project viability and risk assessment.

Canada's Glacier-Climate Observing System is delivered through the multi-lateral initiative "State and Evolution of Canada's Glaciers (SECG)", led by the NRCan - Geological Survey of Canada (GSC). The delivery model for SECG is an integrated monitoring and research collaborative. Contributing partners include other federal departments and agencies, and universities (including several CFCAS initiatives). Glacier – climate observations are derived from the in situ measurements of a network of reference glaciers in the Western and Northern Cordillera and the Arctic Archipelago of Canada. Both aircraft and satellite-based remote sensing are applied in a multi-scale/multi-mode fashion to generate regional perspectives of land ice and its responses to climate variations.

Data for change in length of some Canadian glaciers extend back to the late 19th century. Mass balance measurements were initiated for some glaciers and ice caps in Canada during the late 1950s and early 1960s. Data and supporting metadata on Canada's reference glacier measurements are submitted to the World Glacier Monitoring Service (WGMS). Digital data are stored in the World Glacier Inventory and are also accessible through a website located at the USA National Snow and Ice Data Center. All told, there are 28 mass balance programs records archived internationally at the NSIDC and 24 at the WGMS. These records are also maintained at the GSC.

Currently, sixteen of the Canadian reference sites contribute to the GCOS GTN-G network, with half of these reporting ECVs at protocol intervals to the WGMS. The November 2008 Canadian National Report on Systematic Observations for Climate provides details on the glacier monitoring network and its progress against objectives of the GCOS implementation plan. It is expected that monitoring programs now under development in the Lloyd George, Kananaskis, Nahanni, St. Elias, Baffin Island, and Grise Fjord regions will increase the total contribution to 21 by 2010.

### 8.3.2.4 Terrestrial Systems

The broad scope and multiple agency responsibility for the systematic observation of the terrestrial sector in Canada has resulted in a disparate number of ground-based and satellite-based monitoring programs. There are also planning initiatives in place to improve national coordination of these programs. For example, within NRCan, work in the area of satellite-derived terrestrial ECVs is conducted primarily within two programs: Enhancing Resilience in a Changing Climate and Understanding Canada from Space. The CSA provides substantial financial support to these activities through the Government Related Initiative Program. NRCan's Canadian Forest Service (CFS), in cooperation with AAFC, has established the Canadian Land Cover Community of Practice (LCCoP) with membership from eight federal departments with an interest in land cover mapping.

#### Hydrometric (Water Quantity) Monitoring

EC is the national agency responsible for the collection, interpretation and dissemination of standardized water level and river discharge data and information in Canada. In partnership with Canada's provinces and territories, it operates over 2,400 hydrometric stations, and publishes the data annually in the national HYDAT archive database. Historical data for an additional 5,500 discontinued stations are also stored in HYDAT. Station metadata are stored in the national HYDEX database. The present network is now fully digital and over 1,600 stations transmit data in near-real-time. Similar to the ground-based national meteorological networks, the hydrometric program is well established, with defined standards and operating procedures. The data are published annually and made available in an online archive database. In support of the Global Terrestrial Network – Rivers (GTN-R), Canada

provides data from discharge stations located at or near the mouth of large rivers.

Most of the hydrometric stations are located in the southern half of the country where the population and economic activities are the greatest. As a result, the adequacy of the hydrometric network to describe hydrologic characteristics, both spatially and temporally, decreases significantly to the north. Furthermore, 20% of the network in the north is supported by short-term project-based funding which, if terminated, may lead to station closures in the Mackenzie Basin in the next few years.

Modernization of the hydrometric monitoring system is ongoing. All stations are equipped with digital data loggers and the goal of 100% near-real-time reporting is gradually being achieved. In addition, hydroacoustic technologies have been introduced to facilitate the measurement of velocity profiles. In the next few years, the data acquisition and production components will be modernized with the development of the hydrometric workstation.

At the provincial and territorial level, the Centre d'expertise hydrique du Québec (CEHQ) operates a network of approximately 230 hydrometric stations; 177 of these stations' data are collected by telemetry. The 230 stations are part of the memorandum of understanding between the governments of Canada and Quebec regarding hydrometric monitoring in Quebec.

Owing to its 2006-2012 Climate Change Action Plan (CCAP), Quebec has added to its network new hydrometric stations on ten ungauged priority watersheds, and has restored the operation of 10 hydrometric stations in northern regions, namely in James Bay, Hudson Bay and Ungava Bay. This effort also plans for the modernization of 15 stations annually.

Also within the framework of the CCAP, the CEHQ is currently implementing a hydrological modelling platform on a vast area of southern Quebec. Over the next four years of the CCAP, the CEHQ will use this tool to carry out various studies related to the adaptation of water management to climate change impacts. Among these studies, projections will be made to assess the potential climatic drift of hydrological indicators used in water management, corresponding uncertainty will be estimated, and various pilot projects associated with major issues regarding water management adaptation (management of water withdrawals, dam management, integration of the various uses of water, etc.) will be carried out.

### Canadian forests

Canadian Forestry Service is developing , evaluating and demonstrating methods for estimating above ground forest biomass from models, inventory and remote sensing data at several pilot regions across Canada. EOSD maps provide spatially-explicit information on forest biomass within a national framework of satellite land cover maps of the forested areas of Canada. Mapping outputs contribute to Canada's new National Forest Inventory (NFI) and provide data to the National Carbon Accounting Framework. In addition to biomass mapping, forest biomass can also be derived from Canada's existing national forest inventory (CanFI) which is compiled approximately every five years by aggregating provincial and territorial forest management inventories and reconnaissance level information. Stand-level data provided by the provincial and territorial government agencies are converted to a national classification scheme, and then aggregated to the map sheet, provincial and national levels for storage, analysis and reporting. The most recent version, CanFI2001, is derived from 57 source inventories. NFI takes information from systematically located permanent forest plots across Canada.

Sources of forestry datasets include a range of installed plots, such as the Canadian Forest Service forest health plot network, the provincial growth and yield measurement programs, the national Forest Ecological Land Classification (FEC) plots, selected International Tundra Experiment (ITEX) plots and EMAN installations, cooperative research projects (university and others) and various others. The Forest Indicators of Global Change (FIGC) project, established in 1998, is of particular interest. This project comprises 26 forested sample plots arranged along a 1800km transect extending from northern Ontario to the Bay of Fundy in New Brunswick. The transect comprises plots from the Canadian Forestry Service's Acid Rain National Early Warning System (ARNEWS), plots from the Canada/US North American Maple Project (NAMP) plus new plots selected to fill geographical gaps.

The **Canadian Wildland Fire Information System (CFWIS)** is a collaborative monitoring program between the Canadian Forest Service and the Canadian Centre for Remote Sensing, with co-funding from the Canadian Space Agency. The CWFIS monitors and reports during the fire season (April – October) the daily occurrence of hotspots. The burned areas are mapped, and a national estimate of the annual area burned is used in Canada's National Forest Carbon Monitoring, Accounting and Reporting System to estimate annual emissions from wildfire.

**Fluxnet-Canada** is the Canadian contribution to the Global Terrestrial Network – Carbon (Fluxnet), a network developed to measure the exchanges of carbon dioxide, water vapour and energy between terrestrial

ecosystems and the atmosphere over the Earth's land areas. The Fluxnet-Canada research network was established in 2002 with the help of approximately $12 million of funding over five years provided by NSERC, CFCAS and BIOCAP. The network involved 44 co-investigators from 13 universities, two federal government departments and three provincial research institutes, and operated flux towers at 29 research sites along an east-west continental transect of the commercial forest zone of Canada. These sites were considered to be the minimum necessary to make an effective attempt to address the carbon sink issue in Canadian forests. Twenty-two of these sites were used for long-term, continuous measurements of carbon, water, and energy exchanges between ecosystems and the atmosphere using the eddy covariance flux measurement technique. Non-continuous measurements were also being made at seven additional sites during the growing season. The data from these sites do not account for the impact of disturbances on net ecosystem carbon fluxes, and hence are by themselves insufficient to estimate forest carbon balance. They also require integrated carbon budget models to scale the data from local to national scales. However, they play an essential role in helping to understand and quantify the impacts of environmental variability on sources, sinks and net greenhouse gas budgets. A national database was been created to link a multi-year record of 30-minute carbon flux measurements to long-term changes measured in biomass inventories. Fluxnet maintained a publicly accessible database, containing flux and associated ecological data, which is updated on a regular basis. Fluxnet-Canada ended in March 2007, with much of flux monitoring activities now being undertaken under the Canadian Carbon Program.

**The Canadian Carbon Program (CCP)** was established in 2007, with similar objectives to that noted above for Fluxnet Canada. The data collected under the CPP also helps to reduce the uncertainty of top-down estimates from inverse modelling of carbon budgets on regional, national and continental scales. The research consortium assembled to coordinate and direct research conducted under CCP includes most of the research experts involved in Fluxnet-Canada, but was broadened to include new partners. The CCP represents the Canadian academic community in related discussions with the U.S. and Mexico on CarboNA, a North American Carbon initiative. Canada's involvement in CarboNA is coordinated by Natural Resources Canada. The high-precision measurements of atmospheric greenhouse gases (GHG) fluxes and concentrations acquired through the CCP supplement systematic observations of atmospheric concentrations of CO2, carbon monoxide (CO) and methane (CH4) are undertaken by EC at multiple sites across Canada. Approved funding for this program ends in 2010.

### Coasts

An often cited statistic is that Canada has the longest coastline in the world, approximately 248 000 km. The longest portion of the coast is in the Arctic, and almost all Inuit and Inuvialuit communities in Labrador, Nunavik (Quebec), Nunavut, and the Northwest Territories are located along the coast. In southern Canada, there are growing population centres in coastal regions and on the Great Lakes, and heavy pressure for residential and other development along the coast. Climate changes, including sea level rise, sea ice duration and distribution, storm frequency and magnitude and permafrost thaw, are expected to have significant impacts on all three marine coasts.

NRCan maintains networks of coastal and vertical motion monitoring sites along the Arctic and Atlantic coasts and is working with partners in OGDs, provincial and territorial governments, and industry to estimate risks to infrastructure and human safety in coastal environments. Vertical motion is a critical component of estimates of the impacts of accelerated sea level rise since the relative sea level rise is the sum of the change in height of the oceans and in the height of the land surface. In some parts of the Arctic, the land is rising sufficiently rapidly that relative sea level is falling. However at many coastal sites in Canada, regional postglacial subsidence is of comparable magnitude to current rates of sea level rise and needs to be added to projections of higher relative sea level under climate change.

Vertical motion is monitored using GNSS receivers with antennas on stable monuments to measure mm-scale changes in the vertical position either continuously (at a subset of sites) or episodically. Coastal monitoring is undertaken systematically (annually) at a small subset of sites and baseline surveys followed by later surveys on an opportunity basis (or following major storms) at more than 400 sites in seven provinces and three territories. Periodic surveys measure profiles of beaches, dunes, and cliffs as well as shoreline position, base and top of cliff, or similar features. Two dimensional changes in shoreline positions are also monitored using remote sensing (aerial photography and high-resolution satellite imagery). The extent of airborne LiDAR surveys has expanded dramatically in recent years, enabling development of high-resolution digital elevation models and providing another means of detecting coastal change, including changes in sediment volume. Repeat LiDAR surveys (as undertaken on a regular basis in the US) can be used to accurately depict the impacts of ex-

treme events (hurricanes, winter storms) on the coast.

NRCan works closely with partners in DFO and EC to link observed coastal changes to changes or trends in atmospheric and oceanographic conditions (coastal forcing). Extreme waves, high-water events (storm surges), and direct impingement of sea ice on the shore are among the greatest hazards to coastal stability and associated infrastructure. Changes in the frequency or intensity of these effects may lead to long-term changes in coastal stability, depending in part on sediment supply. Knowledge of past variance and trends can help to discriminate between critical changes and short-term variability.

At the provincial and territorial level, Quebec has had a Forest Ecosystem and Monitoring Network (RESEF) for close to 25 years, which enables it to study, through monitoring, how global changes influence the way forest ecosystems work. Stations are currently being added to complete the network in northern boreal regions. Specific studies are also under way to estimate the effects of climate change on soil fertility and on forest growth and composition in order to include these spheres in the sustainable management of Quebec forests. In addition, scientific works are being carried out to develop improved seed drift models so that parameters specific to climate change can be integrated into Quebec's reforestation management.

#### Agricultural Soils and Vegetation

Agriculture and Agri-Food Canada (AAFC) is a major partner of EC in the operation of a soil temperature network of 28 stations, mostly located at agricultural research stations. Instrument installation, maintenance and data quality assurance and archiving associated with this program are carried out by MSC personnel and every effort is made to follow WMO guidelines and procedures. A broad spectrum of other Canadian agricultural databases also exists, ranging from detailed characterizations of physical and chemical properties of soil to the location and extent of various land use activities and types of vegetation.

AAFC is developing medium-resolution land cover monitoring information for agricultural regions of Canada (30 metre-resolution Landsat data). The AAFC land cover has been developed in coordination with the CFS and provincial land cover initiatives. AAFC has developed a legend and classification methodology which is specific to the needs of the agriculture sector. However, the AAFC legend has been mapped to the Land Cover Classification System (FAO) and the CFS land cover legend. The AAFC land cover monitoring has been developed to support a broad range of agrienvironmental information and application needs, which may include decision support for land use and management; production insurance; development of agri-environmental performance indicators; climate change monitoring plus carbon and GHG accounting and verification; biodiversity monitoring; environmental farm planning and incentive programs for the adoption of beneficial management practices. The land cover monitoring work currently includes a circa 2000 baseline inventory, completed in 2009.

#### Ecological Monitoring

The Ecological Monitoring and Assessment Network (EMAN) was established in 1994 as a national network of ecological monitoring agencies who work together in order to better assess and inform decisions related to ecosystem management. The network is a cooperative partnership of federal, provincial and municipal governments, academic institutions, aboriginal organizations, industry, environmental non-government organizations and community groups. Efforts to date have focused on the creation and implementation of standardized terrestrial ecosystem monitoring protocols, enhanced collaboration among partners, the development of frameworks and best practices to better infom decisions with monitoring results, and the creation of the NatureWatch suite of citizen science monitoring programs. NatureWatch is an Internet based program that includes ice (IceWatch) and plant phenology (PlantWatch) tracking of ecosystem responses to climactic change by volunteer observers. Both programs have grown in participation and scope since their inception in 2001 and 2002 respectively with over 400 observers actively participating in each program. Data collected through NatureWatch are used in assessments of ecosystem change at various scales. Teacher's Guides and associated tools have been developed to support an integrated approach to educating youth about climate change and other environmental issues through the implementation of NatureWatch.

### 8.3.3 Canadian Contributions to Space-based Observations

The Canadian Space Agency (CSA) works in partnership with researchers within the Canadian sciences community to develop spaceborne missions and instruments for observation of the Earth's atmosphere, oceans, cryosphere and land surfaces. Highlights of various projects and missions that are underway or under development as follows:

#### 8.3.3.1 Atmosphere

##### Atmospheric Chemistry Experiment (ACE)

Launched in August 2003, the primary goals of the ACE mission (also known as SCISAT) are to understand the chemical and dynamical processes that control the distribution of ozone in the stratosphere and upper troposphere, particularly in the Arctic; explore the relationship between atmospheric chemistry and climate change; study the effects of biomass burning in the free troposphere; and measure aerosols and clouds to reduce the uncertainties in their effects on the global energy balance. ACE carries two main instruments, a Fourier Transform Spectrometer and a UV-Vis spectrophotometer, and continues to provide valuable information on the depletion of the ozone layer and the distribution and concentration of a large number of greenhouse gases that contribute to climate change, well beyond its original 5-year mandate.

##### CLOUDSAT

Launched in April 2006 as a collaborative Canada-USA project, the CloudSat satellite uses a radar hyperfrequency device to probe the cloud cover and determine its thickness, its altitude at base and peak, and the quantity of water and ice contained. These three-dimensional data of clouds improve our understanding of how they influence the weather and their effect on climate. The data acquired by these scientists is the basis for development of algorithms that will allow derivation of precipitation data products from the CloudSat data.

##### Measurements Of Pollution In The Troposphere (MOPITT)

MOPITT is a Canadian instrument launched in December 1999 aboard the NASA Terra satellite that continuously scans the Earth's atmosphere to make long-term measurements of carbon monoxide concentrations. Initially planned for a five-year term, the experiment has been prolonged because the data collected is still of high quality and the satellite is in good health.

##### Optical Spectrograph and InfraRed Imaging System (OSIRIS)

Launched in 2001, Canada's OSIRIS (optical spectrograph and infrared imaging system) instrument, onboard the Swedish satellite Odin, captures detailed vertical profile measurements of ozone concentration and the formation of ozone holes over the poles. Scientists use OSIRIS data to map concentrations of aerosols and nitrogen dioxide, two major atmospheric components related to pollution and climate. This mission contributes to monitor how human activities affect the atmospheric environment.

##### Stratosphere Wind Interferometer for Transport Studies (SWIFT)

This instrument is currently under development. Once operational, it will advance the knowledge and understanding of the dynamics of the stratosphere, and the role of ozone transport mechanisms. It will also enhance the performance of climate models as well as medium-range numerical weather predications.

##### Canadian Polar Communications and Weather (PCW)

PCW is currently in an early development stage, but should be operational by 2014. This mission is expected to involve two satellites in a highly elliptical orbit that provide a 24 hours / 7 days continuous observation of the entire circumpolar region. One of the primary instruments will be a high resolution imaging spectroradiometer with up to 20 spectral bands covering the entire solar and thermal spectral domains. A broadband radiometer for earth radiation budget observations is also being considered. Observations from this mission will provide valuable information for meteorological forecast applications and for mapping essential climate variables over Canada and the Arctic circumpolar area. PCW will help position Canada as a major contributor to global weather, climate and environmental observation systems, particularly in Arctic regions.

#### 8.3.3.2 Land, Ice and Oceans

##### RADARSAT

RADARSAT-1, the world's first fully operational civilian Synthetic Aperture Radar, was launched in 1995. Despite its original expected time life of 5 years, it still continues to provide valuable information for use in environmental monitoring and natural resource management, particularly over the Canadian northern territory. Its successor, RADARSAT-2, was launched in 2007, with a planned mission lifetime of 7 years. Considered as one of the world's most advanced Earth observation radar imagers, this new system provide a higher resolution, enhanced repeat imaging capacity, shortened programming and processing-delivery timelines, superior data storage and more precise measurements than its predecessor. RADARSAT-2 strengthens Canada's leadership in the development, and operation of advanced Earth Observation technologies and applications.

#### RADARSAT CONSTELLATION MISSION (RCM)

CSA initiated to development of RCM to ensure data continuity for RADARSAT users. Once implemented, the RCM will provide complete coverage of Canada's land and oceans offering an average daily revisit, as well as daily access to 95% of the world to Canadian and international users. This configuration will introduce a new range of applications that are based on regular collection of data and creation of composite images that highlight changes over time. Such applications are particularly useful for monitoring changes such as those induced by climate change, land use evolution, coastal change, urban subsidence and even human impacts on local environments. The first of three satellites of the constellation is scheduled for launch in 2014.

#### New IR Sensor Technology (NIRST)

This collaborative project with the Argentina Space Agency uses Canadian thermal detector technology in an instrument developed monitor temperatures of the ocean surface and record high temperature events such as forest fires and volcanic eruptions. Such data is essential to predicting the mass of greenhouse gases generated by these events. NIRST is one of eight instruments scheduled for launch in 2010 on board of the USA-Argentina Aquarius / SAC-D satellite.

#### 8.3.3.3 Support for Other Countries

EC, through its Water Survey Branch, provides technical and scientific support for the establishment and operation of hydrologic observing systems in developing and emerging countries. The scope of activities, conducted in partnership with the Canadian environmental business sector, include the evaluation, design, and establishment of observing networks and systems; the transfer and sharing of observing knowledge, expertise and methodology; and capacity strengthening in institutional approaches to the long term and sustainable operation of modernized observing networks.

Recent projects undertaken include the reconstruction and modernization of the national hydrometeorological observing network in Poland. An observing network of some 1,000 posts was built and equipped with "state-of-the-art" digital real-time observing technologies. A similar project is underway with the Russian Institute of Meteorology and Hydrology (ROSHYDROMET). Other projects have included activities such as network design and training of water professionals in various countries and regions: under a joint Jordan, Israel and Palestine initiative; in the SADC region of Africa; in the northern basins of Mexico; and in Bangladesh.

The Canadian Forest Service is conducting a cooperative project with the Russian Federal Forest Agency on the application and testing of the Carbon Budget Model of the Canadian Forest Sector to the estimation of forest carbon balances at the regional and national scale in Russia. A bilateral project with Mexico provides support for the application of the CBM-CFS3 in Mexico for the estimation of GHG balances and for the assessment of the carbon implications of REDD strategies.

## 8.4 Research

### 8.4.1 Overview

Canadian climate system and climate change research involves many different scientific disciplines from a broad range of government and academic institutions. The key federal departments involved in such research are EC, DFO, NRCan and AAFC. However, much of the government activities are undertaken in close collaboration with other science-based institutions, primarily within the university community. Many of the Canadian research programs are also linked to larger international efforts. Funding agencies, recognizing the value of such collaboration, have actively promoted and supported the development of research networks and foundations that engage experts from different institutions and from different disciplines. As noted in section 8.2, these include CFCAS, ArcticNet and IPY. As will be seen in the following sections, these programs, together with ongoing government research programs, have already made significant contributions, both nationally and internationally, to the understanding of the climate system, including the carbon cycle, climate trends, the many climate processes that govern the dynamics of the climate system, and the development of advanced climate models used to attribute past changes in climate and to project future climate change. These results have, in turn, helped to better assess how future climate change may impact the Canadian economy, environment and society. However, many unknowns and uncertainties remain.

### 8.4.2 Trends and Variability

Climate analysis makes use of climate observations (physical and chemical), proxy data and climate model outputs over a variety of time and space scales in order to investigate the past, present and possible future characteristics and behaviour of the climate system. Topics of investigation include analysis of trends, temporal and spatial variability, extremes, and the detec-

tion and attribution of climate change. Understanding Canadian climate trends and variability is a fundamental component of the work of EC's Climate Research Division. DFO likewise has a core program dedicated to monitoring and understanding the state and variability of the marine environment. Analyzing the state of the Canadian cryosphere is the responsibility of both EC and NRCan and has been the core part of a larger national program dedicated to understanding the Canadian cryosphere – CRYSYS (CRYosphere SYStem in Canada). Paleoclimate analysis in Canada is led federally by NRCan, with an active research community both in government and academia. The following sections discuss these activities in greater detail.

#### 8.4.2.1 Atmosphere

EC's Climate Research Division has an ongoing program of assessing the current state of the climate, its variability and extreme events. Work on developing homogenized monthly climate station data for temperature, precipitation and wind has been completed and station datasets have been used to generate national gridded time series of monthly anomalies dating back to the early 1900s. These data are also included in the collaborative production of a North American gridded dataset for GCM and Regional Climate Model (RCM) validation. Since 2006, these time series have been updated and improved, using new and better methods for data validation and correction. EC's methods and computer programs for homogenizing climate data are freely available and have been widely used around the globe. The focus of recent work has included:

- the rescue, recovery and verification of lesser known historical climatic data sets that involve climate records of the late 19th century and early 20th century;
- the development of indices for the monitoring and analysis of climate extremes, and of new methods for homogenizing climate data and detecting climate change, including extremes;
- the identification of climate change signals from historical and proxy data at global, national and regional scales;
- and the development of wind/wave hindcasts and future scenarios of extremes for offshore structure design;
- digitizing historical surface pressure data, and making these available to NOAA 20th Century Reanalysis Project

Recent analyses of these data and other by Canadian researchers indicate that an anthropogenic climate change signal can be detected in the pattern of changes global precipitation, in the spatial and temporal distribution of northern high latitude precipitation, and in the Artic sea ice extent. Software tools for the computation of climate extreme indices and for the homogenization of climate data are freely available and have been used world wide. Specific indices to support policy making in agriculture sector have also been developed and published.

The Climate Trends and Variations Bulletin, an internet-based product, is also issued quarterly and annually by the Environment Canada's Climate Data and Analysis Section to inform Canadians about the state of Canadian climate in its historical perspective. The most recent annual summary noted that the national average temperature for 2008 was 0.7C above normal, which was the sixteenth warmest since nationwide records began in 1948. Most of Canada experienced near normal temperatures in 2008, with the north having temperatures a degree or two above normal. With the exception of the springs of 2002 and 2004, seasonal temperatures have remained above normal for more than eleven years, and a longer-term warming trend of about 1.3C over the last sixty-one years has been observed in Canada.

#### 8.4.2.2 Oceans

##### Marine Ecosystems

The oceanography and climate science research program of DFO encompasses analysis, process and modelling research of the oceans and its marine ecosystems. Variability in physical and chemical oceanographic properties, and in biological distributions and production from bacterioplankton to fish is a key area of research. Areas of focus are the Northeast Pacific, Northwest Atlantic, Hudson Bay and the Arctic. Observations from DFO's and other monitoring programs (including atmosphere and ice), remote sensing, and field programs are used to provide descriptions of the state-of-the-ocean off Canada, and of the nature and history of ocean climate variability. The field programs generally involve moored measurements and/or annual surveys, and are typically carried out in conjunction with international programs such as IPY and the international Arctic-Subarctic Ocean Flux (ASOF) in the Arctic, and the UK Rapid Climate Change (RAPID) program in the NW Atlantic. In recent years DFO has started (modest) Climate Change Science and Ecosystem Research Initiatives to focus collaborative research on key issues such as ocean acidification and hypoxia, and on regional ecosystems and climate change impacts.

### Ocean Climate

Our present understanding of the global climate system indicates that there are strong links between the often dramatic changes now happening in many other parts of the world and the behaviour of the climate in the Arctic. Data on the distribution of water-mass properties (temperature and salinity "signatures" associated with currents), on the presence of tracers and contaminants, and on the behaviour of these parameters over time and space are studies in order to understand these linkages.

Global changes in ocean climate are also reflected in the Northeast Pacific by variables such as sea level and sea surface temperature. Episodic variability of physical and biological conditions in these waters can also be caused by global events such as the El Niño-Southern Oscillation. Understanding the nature and causes of variability in our offshore waters is important and provides input to associated research programs that seek to understand the response of coastal ecosystems to such changes.

In the summer of 2004, the warmest surface waters in 45 years of observations were noted along Line P between 127W and 134W. Line P is the time-series program that samples along a transect extending westward from the southern coast of British Columbia to Ocean Station Papa (OSP) at 50N, 145W. Waters were as much as a degree warmer than during the strong El Niño summer of 1997, and exceeded any measurements made during the 1959 to 1981 period in which weather ships were transiting to and from OSP every six weeks.

Warming is leading to an advance in the development of plankton in coastal and oceanic waters. Earlier spring growth is resulting in failures of higher trophic level reproduction (e.g. seabird colonies). The mismatch of predator and prey may extend detrimentally to juvenile salmon. Recent work has shown that warming waters around the Strait of Georgia may have been responsible for failure of the copepod Neocalanus plumchrus, which is likely an essential energy source for migrating juvenile salmon and other coastal organisms.

Fifty years of measurements at Station OPS also show a shoaling (thinning) of the winter mixed layer, a trend that appears constant throughout the subarctic Pacific (since it is reported off Japan also). An important consequence is the reduced ventilation of the subsurface ocean, resulting in declining oxygen levels. Off the coast of British Columbia, oxygen levels have declined by approximately 25% over 25 years at a depth of about 300 m. This information is important for predictions of impacts of climate change on fisheries since the oxygen tolerance of most NE Pacific fishes is poorly understood.

## 8.4.2.3 Cryosphere

### Snow and Ice.

In 2007, at Canada's request, the WMO Congress requested the Inter-commission Task Group (ITG) on IPY to establish an ad-hoc expert group to explore the feasibility of creating a Global Cryosphere Watch (GCW) system to promote sustained polar/cryosphere observations and the development of an authoritative information database on past, present and future changes of our global snow and ice resources. The ad-hoc group was established, with an Environment Canada scientist as chair, and tasked with preparing a related scoping document. The scoping document, submitted to the ITG in April 2009, concluded that there is indeed a need and desire within the international community to create the GCW. The expert team, in collaboration with relevant ITG members and partners, will continue to work on development of the GCW.

### Permafrost

Data collected through the permafrost-monitoring network maintained by NRCan/GSC is being used to characterize recent trends and variability in permafrost conditions across the Canadian Arctic. Data collected since the Fourth National Communication show that the upper 30 m of permafrost continues to warm across the Canadian permafrost region. These results were important contributions to the recently published 4th Assessment Report of the IPCC, UNEP Global Outlook on Snow and Ice and the Canadian report "From Impacts to Adaptation: Canada in a Changing Climate 2007". High Arctic permafrost temperatures appear to be particularly responsive to rising air temperature due to the barren ground surface and cold permafrost temperatures (about -15C) and a lack of unfrozen water to obscure the climate signal. Warming of shallow permafrost at CFS Alert monitoring site (in operation since 1978) has been observed since 2000, consistent with higher air temperatures. These results are similar to those obtained for the Scandinavian high Arctic.

The factors influencing permafrost-climate linkages continue to be investigated in order to better understand the factors affecting the spatial variability of permafrost response to changing climate. Related analysis of changes in thaw depth along a transect in the Mackenzie corridor suggest that factors modulate the linkage between air and ground surface temperatures (such as site moisture, organic layer thickness, vegetation conditions and antecedent winter snow conditions) may be as important in determining active layer thickness as summer air temperatures. Results of modelling studies, utilizing a probabilistic approach, indicate that

thaw depths in the Mackenzie corridor could increase by 15 to 40% over the next century, with smaller increases occurring where thick organic layers are present. Other investigations have focussed on the impact that environmental disturbances such as fires may have on future permafrost conditions. Research projects under the IPY program have also included studies into the role of the magnitude of seasonal influences (such as timing, duration and thickness of snow cover) on permafrost conditions over space and time. These activities, together with the data assimilation projects discussed in section 8.3.2, will provide an important contribution to the IPY project on Variability and Change in the Canadian Cryosphere.

#### Glaciers

In Canada, glaciers and ice caps are found in the Western Cordillera region and in the Arctic Islands. Formal mass balance studies in Western Canada began in 1965 at the inception of the International Hydrological Decade led by the United Nations Educational, Scientific and Cultural Organization (UNESCO). These studies grew from a variety of casual and professional observations dating back to as early as 1896. They were and continue to be centred on the role of glaciers in the hydrological cycle and water resources for human and natural systems. Some recent efforts have demonstrated that the role of glaciers in regulating stream flow may be in decline as the result of significant area-wide reductions in glacier cover. An improved temporal context has been provided by rigorous pursuit of paleo-environmental indicators for certain reference glacier mass balance sites. Most notable is Peyto Glacier where seasonal mass balances have been estimated back to 1673. The role of these glaciers - all generally temperate and at the melting point - as harbingers of climate change has also been emphasized in recent re-assessments and ongoing analysis. This renewed interest in the future of these glaciers has resulted in the creation of the Western Canadian Cryospheric Network, a university-led research network on changes in glacier mass balance established in 2006, with approved funding to 2010. This network has attracted the strong interest of the hydroelectric industry.

Mass balance measurements in the Canadian High Arctic began in 1959. Analysis of more than 40 years of measurements collected since then indicate that all the glaciers and ice caps in this region, with the exception of Meighen Ice Cap, are experiencing weak but significant trends towards increasingly negative balances. Recent research efforts have focused on better documenting the form, flow regime and components of the mass balance (e.g., iceberg calving) of specific ice sheets such as the Devon Island Ice Cap. Much of the work has involved the use of space-based and airborne remote sensing. Historical in-situ mass balance and snow accumulation records have provided critical background information with which to place these more recent observations and assessments in context.

An extensive database review is underway for the period 1995-2005 for reference site mass balance data in order to distinguish a climate or reference mass balance from a hydrological mass balance.

### 8.4.2.4 Paleoclimate

Paleoclimate research in Canada is carried out largely within the university community. However, the Earth Sciences Sector of NRCan also leads a Climate Change Science program that includes research into climates of Canada in the distant past. Activities under this program use geological evidence and other natural archives to (1) provide a long-term context for recent climate observations, (2) evaluate the potential response of critical natural systems to future climates, and (3) provide targets to assess the ability of climate models to simulate past climate change. Paleoclimate research at NRCan has been conducted under two main themes: water resources and Arctic climates.

Studies aimed at understanding the impact of past climate change on Canada's water resources have been conducted in regions where hydrological conditions have a major impact on key sectors such as hydroelectricity, transportation or agriculture. Submerged tree stumps and other geomorphic indicators show that the level of the Great Lakes was lowered by several meters during the early Holocene, which caused lakes Huron and Michigan to become hydrologically closed. This discovery provides a valuable example of past, high-amplitude, climate-driven hydrologic variation that is being used by modelers and stakeholders to improve predictions of the Great Lakes' response to future climate change. Researchers are testing how Hydro-Quebec's generating system may respond to climate change by using tree-ring data to estimate key climate variables for hydrological modeling. On the Canadian Prairies, tree-ring evidence indicates that droughts in the 1720s and 1850s were more severe or more sustained than droughts that occurred after Euro-Canadian settlement. A gradual shift to less frequent droughts and a longer growing season caused Prairie dunes to stabilize during the 20th century. However, because these dunefields were active as recently as 150 years ago, it appears that this ecosystem is highly sensitive to relatively modest changes in the regional climate.

In the Canadian arctic, geological and geophysical indicators are being studied to assess how climate

change affects sea ice and other key aspects of the cryosphere. A multi-proxy reconstruction of sea ice extent shows that the rate and magnitude of the recent decline in sea ice is unprecedented in the last millennium. A synthesis of ice core records from Canada and Greenland also demonstrates that state-of-the-art ice sheet models do not correctly simulate the response of the Greenland Ice Sheet to temperature changes during the Holocene, which suggests that projections of future sea level rise may underestimate the potential contribution from Greenland. In the northwestern sector of Canada, glacier records from Mount Logan in the Yukon Territory have been used to determine whether the teleconnection between the ENSO system and the climate of western Canada has been stable during the Holocene.

Other paleo-climate research activities include:

- The use of cores from arctic ice caps and seabed sediments, as well as whalebone and other fossils on raised beach deposits, to develop an understanding of changes in Northwest Passage sea ice cover over several thousand years and the temperature thresholds associated with these changes.
- The collection of sediment cores by a university team from a unique meteorite crater lake bed in northern Labrador.
- Analysis of vertical motion of the Earth's crust along Canada's coastlines using changes in relative sea level, direct measurements from the Global Positioning System (GPS) and absolute gravity measurements. This information is required to adjust model-derived projections of future sea level for local vertical motion.

A paleo-environmental website hosted by NRCan provides progress and updates on these activities and links to publications.

#### 8.4.2.5 Other Initiatives

##### Canadian Network for the Detection of Atmospheric Change (CANDAC)

This university-led network was established in 2005. It uses the unique Polar Environment Atmospheric Research Laboratory (PEARL) on Ellesmere Island to study atmospheric effects on air quality, climate and the ozone layer. The PEARL facility is one of the world's most northerly continuous atmospheric monitoring facilities and is 1,100 km from the North Pole, at times inside and at others outside the Polar vortex. The facility is managed in collaboration with Environment Canada and the research conducted there involves both Canadian and U.S. scientists. The research component is supported by the Canadian Foundation for Climate and Atmospheric Sciences (until 2010).

##### Storms Studies in the Arctic (STAR)

STAR is a university-based research network that has studied storms and related weather hazards in the northern community of Iqaluit since 2006. It combines field observations, using specially equipped aircraft and ground-based sensors, with computer models to improve the safety of northern communities from weather hazards.

##### Global Ocean – Atmosphere Prediction and Predictability (GOAPP) Network

This new university-led network is a core program within an interagency initiative called CONCEPTS (the Canadian Operational Network for Coupled Environmental PredicTion Systems). It brings together ocean and atmospheric researchers from across Canada into a collaborative effort to improve forecasts of the ocean and atmosphere on time scales from days to decades and spatial scales of tens to tens of thousands of kilometres. The GOAPP partnership includes national contributors (Environment Canada, Fisheries and Oceans Canada, and the Department of National Defence) as well as international contributors such as the French Mercator Operational Oceanography Centre, whose ocean model is currently being adapted for implementation at the Canadian Meteorological Centre (MSC) in Montreal.

### 8.4.3 Biospheric GHG sources and sinks

Canada has a vast land area and relatively small population. While there are opportunities to manage the Canadian biosphere for sustainable reductions in net greenhouse gas emissions, there are considerable risks (and a high likelihood) that the impacts of climate change will result in net emissions for Canada's forests, wetlands and permafrost regions. Mitigation benefits that are achieved through carbon management activities in the biosphere can be reduced or completely negated if climate change impacts result in large increases in GHG emissions, for example through increased incidents of forest fires, insect outbreaks, or drought impacts. There is an urgent need to quantify the potential response of the biosphere to climate change as the direction and magnitude of this response will greatly affect the level of mitigation efforts required if society wants to achieve specified atmospheric GHG stabilization targets. Hence, greenhouse gas sinks and

sources research is an important subset of federal climate systems research. Results demonstrate the complexity of the interactions among the various components of the carbon cycle, and the importance of properly understanding these interactions to ensure our actions to use carbon sinks to reduce our net GHG emissions are robust and verifiable. Related Canadian research activities are focused on understanding and modelling greenhouse gas fluxes from agricultural, forest, aquatic and ocean ecosystems. The acquired knowledge provides the basis for policy advice on enhancement of greenhouse gas sinks as offsets for greenhouse gas emissions, and for adding carbon cycle processes into Canada's climate modelling activities.

Between 2000 and 2007, much of related research within the federal government departments was coordinated and resourced through the Enhancement of Greenhouse Gas Sinks (EGGS) project under the auspices of the federal interdepartmental Panel of Energy Research and Development (PERD). This project culminated with a final workshop in early 2007, and the publication of a final report, Enhancement of Greenhouse Gas Sinks: A Canadian Science Assessment, in 2008.

Greenhouse gas flux research within the federal government departments is undertaken in close collaboration with researchers in academia. Until 2006, BIOCAP Canada (described in section 8.2.2) provided an important role in coordinating and funding the related work of more than 160 university researchers in over 25 Canadian universities. It also helped establish the Sustainable Forest Management Network conducted work in measurement and modelling of forest carbon stock changes. On the subject of aquatic ecosystems and reservoirs, it supported work on, inter alia, the effect of climate, vegetation and other factors on dissolved organic carbon in aquatic systems. Research in the Landscape Scale Cropping Systems network included linkage of upland management practices and GHG dynamics in hummocky till landscapes in Manitoba and Saskatchewan. The BIOCAP program ended in 2006.

#### 8.4.3.1 Agricultural Ecosystems

Since the Fourth National Communication, AAFC has focussed significant research resources environmental issues such as climate change, GHG mitigation and adaptation. Specific activities include:

- understanding nitrogen and carbon dynamics in relation to GHG emissions and removals in agricultural systems;
- understanding and evaluating the influence of agricultural land management on soil carbon reservoirs;
- mitigation of methane emissions in ruminants using dietary and management strategies;
- understanding the nitrous oxide mitigation potential of legumes in no-till cropping systems;
- research, development and implementation of measurement technologies of enteric methane production from cattle to develop emission factors;
- modelling climate impacts on crop biomass production and net GHG emissions and removals;
- modelling of global change impacts to understand how drivers, such as bioenergy policy and climate change will influence agricultural land use and land management systems;
- examination of the impacts of climate change, climate variability and water resources on annual crop production potential;
- development of ecological models to determine risks and benefits of woody perennial crops under climate change;
- assessment of water and nutrient management in an era of scare resources; and
- identifying climate trends and their relationship to changes in land use and land management.

AAFC has also continued research and development of the National Carbon and Greenhouse Gas Accounting and Verification System (NCGAVS) for annual reporting of greenhouse gas emissions and removals from agriculture. NCGAVS is currently funded under AAFC's Growing Forward initiative. AAFC has also developed and released Holos, a farm-level tool for estimating the mitigation potential of changes in agricultural practices. Holos allows users to understand how changes to a farming system will influence relative carbon and GHG costs and benefits. The publication, Better Farming, Better Air, A scientific analysis of farming practice and greenhouse gases in Canada (Janzen et al, eds.), developed in conjunction with the Holos system and released in 2008, provides a summary of agriculture GHG mitigation and adaptation information resulting from climate change research programmes since 2000.

The new AAFC policy framework, Growing Forward, includes the programme Sustainable Agriculture Environmental Systems (SAGES) that focuses on agriculture's contribution to clean water and clean air. SAGES supports development of science required to maintain effective environmental programs and policies and to

address crosscutting issues such as climate change, water management, and geospatial technology development. SAGES seeks to improve understanding of processes and mechanisms by which agricultural practices affect water quality (nutrients, contaminants), and affect or is affected by climate change drivers and outcomes.

### 8.4.3.2 Forest and Aquatic Ecosystems

#### Canadian Forestry Service and Canadian Space Agency

NRCan's Canadian Forest Service continues to conduct research on the contribution of forests to the GHG balance, the impacts of climate change on forests, including potential feedback mechanisms, and on the development of climate mitigation and adaptation strategies in the forest sector. Examples include:

- understanding how forest growth and mortality, forest composition and geographic distributions may change under a changing atmosphere;
- quantifying carbon stocks and stock changes as affected by human and natural disturbances using both inventory based empirical models and process-based simulation models;
- monitoring land-use change involving forests to quantify the impacts of deforestation in Canada on GHG emissions and removals;
- long-term studies of decomposition rates of forest litter across Canada;
- a National Forest Inventory system that provides monitoring information and data on carbon in biomass, dead organic matter and soil carbon pools required for monitoring and model validation;
- demonstrating the feasibility of afforesting underutilized land to sequester carbon in the near-term;
- evaluating the impacts of different harvesting practices on riparian ecosystems in light of changing forest conditions due to decreasing moisture and increasing temperatures;
- estimating and monitoring the effects of wildfire and insect disturbances on the carbon balance, GHG emissions and indirectly on forest health and productivity; and,
- monitoring the biomass, growth and health of aspen forests in climatically sensitive areas of the western boreal forest and aspen parkland.

The Canadian Forest Service is the lead on the development of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3). This model is also at the core of Canada's National Forest Carbon Monitoring, Accounting, and Reporting System, a Tier 3 forest accounting system fully compliant with IPCC reporting guidelines. The CBM-CFS3 is freely available (http://carbon.cfs.nrcan.gc.ca) and is supported with a User's Guide, tutorials, training workshops and technical assistance provided to users. Over 200 analysts have been trained in the use of the model, and training workshops have included participants from over 20 countries, including representatives from developing countries supported by NRCan. Application of the model has reduced the uncertainties regarding the net carbon balance from the forest sector (both forest ecosystems and forest products), and provided a clear demonstration of the impacts of large-scale natural disturbances, forest management and land-use change on GHG emissions and removals.

The Canadian Space Agency contributes to these activities through two collaborative projects. It has worked with CFS to develop methods of using space-based observations for consistent, timely and spatially precise mapping and monitoring of the location, extent and severity of forest disturbances in support of Canada's national and international reporting requirements on environmental and sustainable development indicators and carbon accounting. It has also collaborated in the development and testing of a system that integrates existing satellite-based and other observational spatial datasets to provide maps and information products suitable for reporting activities associated with Land Use, Land-use Change and Forestry. Such information is important in estimating greenhouse gas fluxes that are lined to such activities.

#### Fluxnet-Canada

As described in section 8.3.2 on Monitoring Networks, Fluxnet-Canada's research program added to the current understanding of carbon cycling and storage in Canada's forests and peatlands and the role that these ecosystems play in the global carbon cycle. While climate-induced changes will almost certainly affect the stores of carbon in the terrestrial biosphere, the most important factors influencing the terrestrial carbon cycle are likely to be land use activities and natural disturbance. Fluxnet-Canada therefore focused many of its measurements on disturbed sites to understand how forest management, natural disturbance and wetland creation influence carbon cycling.

One of the key scientific results from the network is the quantification of harvesting impacts on the

source/sink status of Canada's forest ecosystems. A network-wide synthesis showed large differences in net carbon uptake related to age since disturbance (fire or logging) and to ecosystem type (broadleaf forest versus conifer forest versus peatland). Middle-aged stands (35-60 years old) had the greatest rates of carbon accumulation. Another key network result is the large impact of year-to-year climatic variability on the forest carbon sink. Researchers at a Douglas-fir site in British Columbia found that warmer temperatures associated with El Niño caused an increase in carbon emissions, reducing the net amount of carbon sequestered. Combined measurement and modelling activities at a boreal aspen site in Saskatchewan showed that the positive impacts of spring warming on forest carbon sequestration could be offset by the negative impacts of increased summer drought. Fluxnet-Canada terminated activities in 2007, however its work continues in an expanded form through a successor network, the Canadian Carbon Program.

#### Canadian Carbon Program

The Canadian Carbon Program is jointly funded by CFCAS and NRCan, and led by Universitè Laval. The major deliverable of the Canadian Carbon Program (CCP) is the development of a scientific framework for reducing uncertainty in estimating the C budget of Canada and North America at monthly to multi-annual time scales through a coordinated program of measurements and modelling. The CCP involves scientists in both academia and government agencies such as NRCan's Canadian Forest Service, EC's Atmospheric Sciences and Technology Directorate, and NOAA's Global Monitoring Division. Activities under the CCP include the measurement of ecosystem gas fluxes, atmospheric concentrations of greenhouse gases (and their precursors), and ecosystem component processes. Researchers involved also use data from remote sensing of land surface properties and from forest inventories acquired through other monitoring programs. For example, scientists from the CCP and the Canadian Forest Service have collaborated on two regional studies of historic ($\sim$ 80 year) forest carbon fluxes and used the case studies to compare inventory and process-based simulation models and their ability to reconstruct forest carbon balances affected by natural disturbances and forest management. The CCP works in collaboration with related efforts in the US and Mexico within the framework of the North American Carbon Program (NACP). The combination of high-quality field measurements and coordinated modelling within the CCP are essential to the development of a scientific framework for an integrated C-cycle monitoring and prediction system for Canada.

By helping to understand the sensitivity of Canadian forests to climate and disturbance, the results of the research undertaken under the CCP will help to develop a predictive capability for analyzing the effects of different climate scenarios on future C stocks. Not only will it permit large-scale estimates of C sources and sinks for given periods of time, but it will also allow analysts to attribute mechanisms to the observed phenomena and enable them to predict C sequestration/emission scenarios with respect to climate change. The CCP will provide valuable information on the sensitivity of Canadian forests to climate and disturbance that can be integrated into the Canadian Forest Service's CBM-CFS3 model, which forms the core module of Canada's National Forest C Monitoring, Accounting and Reporting System (NFCMARS). This information also help's to develop Canada's capacity to model the effects of climate change and forest management practices on C stocks.

### 8.4.3.3 Ocean systems

DFO research programs seek a better understanding of the processes that control the flux of GHGs into, within and out of ocean systems, assessing the potential and verifiability of measures to enhance oceanic GHG uptake (including environmental risks and consequences). The primary objective of this ocean processes climate research is "getting the carbon right" by reducing the uncertainties in coupled ocean-ice-terrestrial-atmosphere models. The communication of such information to policy makers is important as a scientific basis for the international discussions regarding ocean based GHG sequestration programs.

For the last several decades at least, the oceans have removed up to half of the CO2 emitted into the atmosphere from human activities. The key scientific question being addressed is whether the oceans will continue to sequester this CO2 and whether the oceans can sequester even a larger fraction of CO2 emissions through purposeful fertilization. Making progress in this area requires the continued integrated approach of careful observations and model development from local to global scales.

## 8.4.4 Climate Processes

Climate processes research addresses issues related to how the climate system functions. These issues include the role of clouds, the oceans, sea ice, permafrost, and land surface processes in the climate system, as well as the function of forests, agriculture, wetlands, and oceans in the global carbon cycle. Proper understanding of these and other processes is required to predict

future climate with greater certainty to support actions on mitigation and adaptation. Expertise in this area is concentrated primarily within universities and a number of federal government scientific institutions. Federal and university-based research is integrated through a number of major collaborative research programs. The Canadian federal government core programs also programs include studies of atmospheric and ocean processes, the water and energy cycle and the cryosphere.

### 8.4.4.1 Land

Research in tundra and taiga environments has resulted in a better understanding, quantification and modelling of critical components of the water and energy cycles in the climate system. For example, as part of the Mackenzie GEWEX, EC scientists and their colleagues have determined how much water originates outside the basin and how much is recycled within the basin in warm and cold seasons.

#### MAGS

Canada's supply of fresh water exceeds that of any other nation, but naturally occurring climatic changes cause these water resources to fluctuate enormously. The Mackenzie River Basin is a 1.8-million square kilometre area in northwestern Canada that is the largest North American supplier of fresh water to the Arctic Ocean. For 12 years, Canada supported a major collaborative research program into cold climate energy and water cycles through MAGS, which was part of Canada's contribution to a global study under the WCRP. This cross-disciplinary study involved about 100 scientists and engineers from university and government sectors. The goals of MAGS were 1) to understand the circulation, storage and distribution of water and energy in the Canadian north and 2) to improve our capability to predict the impacts of human activities and climatic changes on the northern environment. A final workshop was held in 2006, during which the International Advisory Panel gave high praises to MAGS for its significant contributions to the International GEWEX. Although the MAGS research network ended in 2006, high latitude water and energy cycle research has continued through other funded initiatives such as the IP3 research network and EC-led IPY network projects "Arctic Freshwater Systems: Hydrology and Ecology" and "Variability and Change in the Canadian Cryosphere".

### 8.4.4.2 Cryosphere

Much of the research with respect to cryospheric processes within the climate system has been led by EC and NRCan as part of the core of their program activity. New satellite capabilities for retrieval of snow cover information for northern boreal forest and tundra landscapes have been developed and validated through intensive field campaigns in northern Canada involving ground-based measurements and aircraft remote sensing. Work was completed that sought to improve the representation in models of various processes affecting snow cover in cold regions. One significant outcome was the incorporation and testing of five improved snow cover parameterizations in the Canadian Land Surface Scheme model (CLASS), which provides comprehensive state-of-the-art land surface modelling capability in the Canadian Global Climate Model (CGCM), the coupled Canadian Regional Climate Model (CRCM), and weather forecast models. CLASS version 3.4 has now been documented and released with enhanced snow, soil and vegetation parameterizations. This version of CLASS is being integrated into Canadian climate models to improve the parameterization of land surface processes and land-atmosphere exchanges. CLASS is also being evaluated as part of the CFCAS research network "Improved Processes and Parameterisation for Prediction in Cold Regions", IP3. IP3 will develop an improved understanding of cold regions hydrometeorology and test advances in atmospheric and hydrological prediction in the Rocky Mountains and the Arctic along a transect of high latitude and high altitude instrumented research sites that characterize the cold regions of Canada.

#### CASES

The environmental, socio-economic and geopolitical consequences of arctic climate change will be tremendous. Understanding the nature of climate change in the Arctic is critical to Canada and to the global community. Toward that goal the Canadian Arctic Shelf Exchange Study (CASES) Research Network was funded in March 2001 by NSERC to conduct CASES. CASES is an international effort under Canadian leadership to understand the biogeochemical and ecological consequences of sea ice variability and change on the Mackenzie Shelf in the Beaufort Sea (Arctic Ocean). Supported by funding of $10.5 million over five years from NSERC, the network brings together over 70 leading experts in polar science from 13 Canadian universities, four federal departments (DFO, EC, NRCan and the Department of National Defence) and eight foreign countries. The Canadian Coast Guard and Québec-Océan provide the administrative, logistic and navigational expertise needed for an arctic endeavour of this scope.

The main thrust of the CASES field program was

the sustained one-year expedition to the study area from September 2003 to August 2004, on board the CCGS Amundsen, the new Canadian research icebreaker. Over 225 Canadian and foreign scientists took turns on the ship to study all aspects of the Arctic ecosystem over an annual cycle. In all, the unprecedented CASES field program will provide a three-year inter-annual comparison of the ecosystem maturation in response to sea ice cover variability, and, for the first time ever, a year-round, highly-integrated, multidisciplinary study of an arctic shelf ecosystem, including a segment of the circum-Arctic flaw polynya system. Most importantly, time-series of key measurements initiated during CASES will be pursued within the framework of ArcticNet.

Funding for CASES ended in 2007. However, the program has helped train a new generation of arctic specialists, and has contributed to the revitalization of Canadian leadership in Arctic sciences. Its results will also help to provide more accurate predictions of the extent, intensity and environmental impacts of climate warming in the Arctic.

#### 8.4.4.3 Oceans

DFO and university researchers have continued investigations of the processes involved in ocean and coupled atmosphere-ice-ocean climate variability, using models and interpretations of existing and new observations. Research teams have been investigating the storage and transport of heat, freshwater and carbon in the North Atlantic, North Pacific and Arctic Oceans through field expeditions, data analysis and model simulations. These studies have provided better knowledge of the transports through the Canadian Arctic Archipelago in recent decades, the production of intermediate-depth water masses in the Labrador Sea, and the linkages of these processes to the larger-scale circulation in the North Atlantic. This is important since Arctic outflows and Labrador Sea Water play important roles in the strength of the global oceanic thermohaline circulation which is expected to be an important factor to climate impacts in eastern Canada and Europe in particular.

##### Canadian Surface Ocean Lower Atmosphere Study (SOLAS)

Bounded by three oceans, Canada has a vital interest in the impact of changing ocean processes on weather patterns, resources and transportation. The Canadian SOLAS (C-SOLAS) research network was part of a new international initiative aimed at understanding the interactions between the oceans and the atmosphere as well as the implications of those interactions for global climatic change. Initiated in 2001 with the support of funding from NSERC, CFCAS and DFO, the C-SOLAS network involved 43 researchers from nine universities, 22 government researchers from DFO and EC, two industrial collaborators and a growing number of international partners. Together, they examined the key interactions between the marine biochemical system and the atmosphere, and the impact of these interactions on climate change. With four major research expeditions successfully completed and reported on at the first SOLAS International Open Science Conference held Halifax, Nova Scotia, Canada in 2004, the C-SOLAS community had positioned itself as leader in the International SOLAS program. Funding for the Canadian SOLAS community ended in 2006.

#### 8.4.4.4 Polar Regions

**ArcticNet** (described in section 8.2.2) brings together scientists and managers in the natural, human health and social sciences with their partners in Inuit organizations, northern communities, government and industry to help Canadians face the impacts and opportunities of climate change and globalization in the Arctic. Over 80 ArcticNet researchers and 200 graduate students, post-doctoral fellows, research associates and technicians from 23 Canadian universities and five federal departments collaborate on 25 research projects with more than 100 partner organizations from Canada, the USA, Japan, Denmark, Norway, Poland, the United Kingdom, Spain, Russia, Greenland and France.

In anticipation to this second phase of funding, ArcticNet held a general call for proposals in the fall of 2007 to develop its Phase II (2008-2011) research program. After an extensive review process, 27 projects were selected in March 2008 to form the core of the research program until March 2011. A total of 110 Network Investigators are now funded as part of ArcticNet, including 43 new researchers. ArcticNet's Phase II research program continues to boast a multidisciplinary approach with the breadth of research topics including the monitoring and modelling of climate indicators, the study of infrastructure destabilization, marine and terrestrial ecosystems, geopolitics, and the socio-cultural and health impacts of climate change.

ArcticNet has been pivotal to the revitalization of the Canadian Arctic research program and has been a catalyst for changing the way northern research is conducted in Canada. First, ArcticNet has proved a unique opportunity for a much-needed alliance of researchers and Inuit in the study of the changing Arctic. Second, ArcticNet is breaking barriers between the natural, socio-economic and human health research sectors. Arctic specialists from all fields of research are

joining forces through ArcticNet to integrate their respective contributions to study the consequences of the present transformation of the coastal Canadian Arctic. Third, due primarily to the coordination of community visits, the logistical support of partners and the central piece of infrastructure – the research icebreaker CCGS Amundsen - ArcticNet is providing Canadian scientists and their international collaborators with unprecedented access to the coastal Canadian Arctic and its communities.

Finally, ArcticNet is encouraging Network Investigators to incorporate their research project into one of several Integrated Regional Impact Studies (IRISes) around which the scientific program of the Network is built. ArcticNet therefore clearly encompasses all aspects of climate change research, from monitoring environmental change in the Arctic, to improving our understanding of Arctic climate processes, and to building that knowledge into improved regional scale projections of change in order to evaluate potential impacts and adaptation responses.

## 8.4.5 Climate Modelling

Climate modelling research in Canada is undertaken in both federal government research facilities and in universities. Canadian scientists are also extensively engaged in research collaborations with international colleagues, working on projects to improve the representation of various physical processes in global climate models. For example, Canadian scientists with the CCCma participate in the WCRP Working Group on Climate Modelling and the WCRP Observation and Assimilation Panel, and on the WCRP Working Group on Seasonal to Inter-annual Prediction. In addition, Canadian scientists continue to play an important leadership role in international climate research coordination and assessment bodies, such as the International Geosphere-Biosphere Programme (IGBP), WCRP and IPCC.

The Canadian research community also devoted considerable effort to improved understanding and modelling of high-latitude climate as part of a dedicated contribution to the International Polar Year.

### 8.4.5.1 Global

Global climate models (GCMs) are the primary tool for making quantitative projections of future climate change. These models are based on mathematical representations of physical processes that include the three-dimensional atmosphere and ocean, along with sea ice and the land surface (and its vegetation). GCMs are used in two kinds of simulations. The first is a long 'control' run of the model with no change in atmospheric composition or other external forcing. This kind of simulation is used to understand the processes involved in natural climate variability, and to estimate the magnitude of this variability for climate change detection studies. The second kind of simulation involves specified changes in forcing such as GHG concentration and aerosol loading. This kind of simulation is used to understand (and attribute) historical climate change, and to make future climate change projections.

#### Environment Canada Activities

The core Canadian GCM effort is housed within Environment Canada, at the Canadian Centre for Climate Modelling and Analysis (CCCma) in Victoria, British Columbia. This group has been developing and applying an increasingly comprehensive progression of GCMs since the 1970s. In addition, the CCCma plays a central role in collaborative climate research with Canadian university partners and other government departments, notably DFO, who contribute expertise in ocean carbon cycle modelling. The CCCma global climate model is highly regarded internationally and CCCma scientists serve on a variety of national and international steering committees and working groups.

The CCCma's current model, CGCM3, has been used to provide the Canadian contribution to the IPCC coupled model archive, results of which constituted a significant component of the IPCC Fourth Assessment Report. The Canadian contribution included results from two versions of CGCM3: one with a resolution of T47 (approximately 3.8°lat/lon atmosphere and 1.9°lat/lon ocean); and one with a resolution of T63 (approximately 2.8°lat/lon atmosphere and 0.9°x 1.4°lat/long ocean). A more complete description is available on the CCCma website. Results from both versions have been extensively used in model intercomparisons.

CCCma has also collaborated with the university community on the development of the CRCM. This model is used to provide higher resolution climate change information for Canada, and is driven at its boundaries by output from the CCCma global model.

Output from both the global and regional models is available to the public via the CCCma website. This website allows a user to select specific model variables, from all or part of the model domain, and download it for use in climate change research, impact assessments and the like. There are almost 1,900 registered users of this website, and, on average, there are over 350 data downloads per month.

A new version of the Canadian Global Climate Model, CGCM4, has been developed. Drawing on re-

search undertaken over the past few years, it includes improved representation of radiative transfer, cloud processes, ocean mixing and numerical computation methods. In addition, it includes an explicit representation of the sulphur cycle and hence the direct and indirect sulphate aerosol effects. A parallel effort to develop of a model version with an interactive carbon cycle has culminated in the first comprehensive climate model in Canada with representation of terrestrial and ocean carbon cycle processes. This model, known as the Canadian Earth System Model (ver. 1) – CanESM1 – includes interactive carbon, sulphur cycles, along with dynamic vegetation and an ocean ecosystem.

A new version of the CRCM is also under development, taking advantage of the improved representation of physical processes in CGCM4, and the availability of a new, and more flexible, dynamical core developed for operational numerical weather prediction. This new CRCM will be used to provide higher resolution downscaling of future climate change projections.

The gap between Numerical Weather Prediction and Climate Modelling is steadily narrowing through the use of coupled (atmosphere-ice-ocean) forecast systems and ensemble forecasts at seasonal to interannual time scales. In Canada, work is progressing on improving our seasonal forecast capability by using coupled models with data assimilation. An experimental coupled seasonal to interannual climate prediction system is now being extensively tested, and includes assimilation of ocean data, atmospheric data, land surface data, and sea ice data to provide initial conditions for such forecasts. Of particular importance is the participation in various 'historical forecast projects' which provide a means of quantifying model predictive skill.

### University networks

A large portion of this research is done in collaboration under various national research networks. With funding from CFCAS and NSERC, a number of networks have recently been established that investigate various aspects of the research necessary to improve both the Canadian regional and global climate models. These include:

- **CGC3M** (Canadian Global Coupled Climate Carbon Model) network was established to develop terrestrial and oceanic ecosystem models that could be included in the CCCma climate model in order to represent the global interactive carbon cycle. The activities of this network ended in 2008.
- **MOC2/CAFC. MOC2** (Modelling Clouds and Climate) was a collaborative program concerned with improving our ability to represent cloud and aerosol processes in the CCCma climate model. The activities of this network ended in 2006. However, similar research continues under a successor network called CAFC.
- **CAFC** (Cloud-Aerosol Feedbacks and Climate) is a research network aimed at reducing uncertainties associated with the representation of clouds and their interaction with aerosols and radiation in the Canadian Global Climate Model. Detailed chemical and microphysical experiments are being conducted by the Network to close important data gaps and facilitate robust tests of the model parameterizations. Observational data is also being used to test and develop new and improved model parameterizations and further advance Canadian climate modelling capabilities. The network represents a partnership between four universities and Environment Canada. Funding for CAFC terminates in 2010.
- **GCC** is a project on Modelling of Global Chemistry and Climate and involves an upwardly extended version of the CCCma atmospheric model with a sophisticated chemistry package to represent climatically relevant processes (such as ozone depletion) in the upper atmosphere. The activities of this network terminated in 2006. Some of the elements were taken up by a new research network called C-SPARC.
- **C-SPARC** (The Canadian - Stratospheric Processes and their Role in Climate program) is linked to the international SPARC initiative of the World Climate Research Programme. This program helps to extend the CCCma atmospheric model upward and add a sophisticated chemistry package to represent climatically relevant processes (such as ozone depletion) in the upper atmosphere. Funding for C-SPARC ends in 2010.
- **CSHD**, the Climate System History and Dynamics Network, is a multidisciplinary collaborative effort that made use of paleoclimate reconstructions to evaluate climate model response to past climate forcing, particularly conditions during the last glacial maximum.
- **GOAPP**, the Global Ocean Atmosphere Prediction and Predictability project, provides a significant improvement in the ability to assimilate ocean data into ocean models, and to use this capability to develop a fully coupled seasonal to interannual prediction system.

### 8.4.5.2 Regional

**CCRM** was a research network aimed at developing an improved capability for regional climate 'downscaling' in Canada, making use of a regional model that is physically consistent with the CCCma global model. Although the activities of this network ended in 2006, its work has been sustained and expanded under a new initiative, **CRCMD** (the Canadian Regional Climate Modelling and Diagnostics Network). The activities of CRCMD are supported by CFCAS, in partnership with *Ouranos*, a provincial (Québec) consortium on climate sciences, impacts and adaptation.

A new version of the CRCM is also under development, taking advantage of the improved representation of physical processes in the CGCM, and the availability of a new, and more flexible, dynamical core developed for operational numerical weather prediction. This new CRCM will be used to provide higher resolution downscaling of future climate change projections.

Finally, the Canadian research community will be devoting considerable effort to improved understanding and modelling of high-latitude climate as part of a dedicated contribution to the International Polar Year.

In Quebec, Montreal is the main scientific pole for regional climate modelling in Canada. The Ouranos Climate Sciences program, together with its Climate Simulations group and UQAM's Centre pour l'étude et la simulation du climat à l'échelle régionale (ESCER), have shaped science in this field over the past 20 years and have formed substantially all of the highly qualified personnel working in this science field in Canada. Up until 2001, UQAM was the only centre of activity in this field and developed the prototype for the Canadian regional climate model (CRCM).

With the creation of the Ouranos Consortium in 2002, Quebec equipped itself with a reliable source of information in regional climatology. The Consortium developed all operational versions of the CRM as well as the production infrastructure (the simulation management programs), and made all regional climate simulations (for current climate) and projections (for future climate) across Canada. Among its many accomplishments is the very first regional climate projection across North America as well the creation of an exceptional database of regional climate simulations and projections. Internationally, Ouranos participates in international programs and collaborates on regional climate modelling such as the North American Climate Change Assessment Program (NARCCAP), the ENSEMBLES European project and the Bavaria/Quebec project.

It is interesting to mention that Ouranos is also working on producing climate scenarios adapted to the needs of users and on developing methods to analyse and enhance the climate information produced

## 8.4.6 Climate Scenarios

Research into the sensitivities and vulnerabilities of ecosystems and socio-economic activities to climate change can take different approaches. On the one hand, it is instructive to understand how sensitive systems are to current climate variability in order to understand the ways in which systems could become stressed in the future with a changing climate. On the other hand, in order to consider how climate may change in the future, when past norms no longer provide appropriate guidance, insight is sought from climate change scenarios, which are developed at the appropriate time and space scale, for the system in question. The GoC has clearly recognized the value in facilitating the provision of climate change scenarios to those in Canada engaged in impacts and adaptation work.

The Canadian Climate Impacts Scenarios Facility was originally established in 1999 to provide climate change scenarios from over 40 projections from various international modelling centres to users involved in climate change studies. It also provided training on related model output downscaling software. The CCIS project ended in 2004. The GoC launched the Climate Change Scenario Network (CCSN) in 2005 to expand this service and improve the links to the impacts and adaptation's research community. The CCSN was established as a national network, coincident and co-located with EC's Adaptation and Impacts Research Division (AIRD), with nodes in each region of the country, located within universities, with the exception of Québec, where the regional node is housed with the Ouranos Consortium (Québec's flagship impacts and adaptation partnership.) AIRD manages the network, and AIRD researchers located with the regional nodes facilitate scientific support to the network. The CCCSN continues to support climate change impact and adaptation research in Canada and other partner countries through the provision of GCM scenarios, RCM scenarios and downscaling tools. In addition, the CCCSN can provide high level technical support for downscaling and impacts and adaptation research, access to existing research, access to new research tools as they are developed at the AIRD nodes and training in the use of these tools. The CCCSN supports academic researchers as well as other stakeholders outside of academia who require scenario information for decision-making. The content of the network includes:

- Canadian climate change scenarios derived from GCM (Global Climate Model) simulations, (particularly the Canadian model, available at the

Canadian Centre for Climate Modeling and Analysis (CCCma), those scenarios recommended by the Intergovernmental Panel on Climate Change (IPCC) and the Program for Climate Model Diagnosis and Intercomparison (PCMDI) project;

- regional scale/high resolution output from the Canadian Regional Climate Model (CRCM), through collaboration with the Ouranos consortium, along with information on other relevant GCM downscaling methods;
- Bioclimate profiles for Canada;
- Scenarios and impact and adaptation research documents from within and outside of Canada;
- Links to IPCC guidelines on scenario use and interpretation;
- On-line instructions for using scenarios and downscaling tools: the Statistical Downscaling Model (SDSM), the Automated Downscaling Tool (ASD) and a weather generator (LARS-WG);
- Links to other tools used in impacts and adaptation research; and
- Scenario Reports and selected scientific publications related to climate scenarios and impacts and adaptation research. DFO's new Climate Change Science Initiative also includes a small component on Predictions and Scenarios which is developing climate change scenarios or projections for use in identifying potential and probable impacts of climate change on Canada's marine ecosystems.

### 8.4.7 Biophysical Sensitivities

A further subcomponent of climate process research is that which seeks to improve understanding of the biophysical sensitivities of systems to climate and climate change. Research on the biophysical aspects of sensitivity is one component of determination of vulnerability, which is defined as the degree to which a system is susceptible to, or able to cope with the effects of climate, including extremes. Research on the biophysical sensitivities of both unmanaged and managed resources to changes in climate is conducted mainly by federal departments through a mixture of A-base funding and funding from other programs such as the CCAF.

EC's Aquatic Ecosystem Impacts Research Program and the Water and Climate Impact Research Centre (W-CIRC), jointly established with the University of Victoria, conducts a national, interdisciplinary program of ecosystem-based research in the aquatic sciences which includes research on hydrological and ecosystem processes that contribute to our understanding of the biophysical sensitivities and vulnerabilities of freshwater systems to climate variability and change. The program focuses on identifying, quantifying, and modelling hydrologic and ecological impacts of climate change and variability. Major activities related to biophysical sensitivities included: developing suitable indicators of hydrological and ecological response; detecting and predicting trends in key hydrologic variables, water resources and aquatic systems sensitive to hydroclimatic extremes and variability; determining and modelling how climatic alterations affect hydrologic, geochemical and ecological processes at local and regional scales. A special focus is also placed on sensitive aquatic systems, such as the bellwether systems identified in the Arctic, or highly valued water resources that are under increasing stress from synergistic effects of resource extraction/consumption and climate variability.

Much of the work on biophysical sensitivities to climate variability and change conducted by EC and its partners is regional in nature. In northern and western Canada, researchers have examined the sensitivity of transboundary waters to changes in extreme events such as floods and low flows. Researchers are also examining past trends and variability in hydro-climatology and constructing future climatic scenarios of hydroclimatic conditions. In the Okanagan River basin, the implications for water quality of a projected earlier spring flood and decline in annual flow volume have been examined, in light of ecological needs and growing demand for irrigation and other human uses. In the Prairies, hydrologists are monitoring water balances in wetlands and generating hydrological models that can be used to analyze and predict the impacts of climate change and land use change.

In the Great Lakes basin, groundwater experts are modelling groundwater and climate interaction, and assessing the combined impacts of climate variability, climate change, and water use on groundwater dependent water supplies, in-stream conditions, and aquatic habitat. Scenarios of future climate change also suggest lower water levels in the future for the Great Lakes - St. Lawrence system – a consequence of particular concern for coastal ecosystems such as wetlands, and human activities such as recreation and shipping. Under the International Joint Commission Upper Great Lakes Study there are also several projects on coupled land, lake, and atmosphere modelling. One of these, led by EC, seeks to develop a fully coupled land, lake and atmosphere regional climate modelling system which can be used to evaluate individual terms of the water budget

of the Laurentian Great Lakes basin for both current and future projected climate conditions. This model will provide the best long term climate simulations for the Great Lakes region to date, and will help determine whether natural climate variability, along with known diversions and consumptive use, is sufficient to explain lake level variability.

In the Arctic, EC has led an assessment of climate change impacts on Arctic freshwater ecosystems and hydrology, and on river flow to the Arctic Ocean. In the Mackenzie Delta region specifically, scientists are analyzing the role of climate in catastrophic lake drainage, and analyzing peak spring water level to determine climate-related variability in the spring break-up flood; they are also working to improve models for climate change impact prediction; establishing surface energy balance over heterogeneous terrain and comparing with tower and aircraft estimates; and conducting analysis of the heat and mass exchanges of lakes.

Research results provided Canadian contributions to major international assessments and/or planning exercises such as those conducted by the Intergovernmental Panel on Climate Change (IPCC), Arctic Climate Impact Assessment (ACIA) project, International Conference on Arctic Research Planning (ICARP) and UNESCO International Hydrological Programme (IHP).

## 8.5 Climate Science Assessment

Formal scientific assessments of the state of understanding on complex scientific issues have become an important way for scientists to convey advice to decision-makers on matters requiring policy decisions. Canada recognizes the value of such activities, and continues to support Canadian involvement in international assessments, and undertake national, regional and sectoral assessments of climate change. Furthermore, to support such activities, and to provide ongoing science advice on climate change (and other atmospheric issues) to Canadians and to the GoC, EC maintains an Atmospheric Science Assessment and Integration (ASAI) group. Assessment of the scientific literature on climate change is a core ongoing activity for this group, and weekly as well as annual reviews of the literature are published on-line. A review of such literature for 2003-2005 was completed in 2006. A follow-up review of the literature over the period 2006-2008 was completed in 2009. The group also maintains the educational site on the science of climate change for EC.

EC's National Water Research Institute (NWRI) leads and publishes scientific assessments of priority freshwater issues in Canada, including stresses on water availability in Canada, an issue tightly linked to climate change.

NRCan manages the federal CCIAP under which a new national-scale assessment of climate change vulnerability, impacts and adaptation has been launched (see chapter 6).

Canada has continued to support the involvement of Canadian experts in assessments by the IPCC, including the Fourth Assessment Report (AR4). Of the 79 Canadians contributing to AR4, twenty-nine Canadian experts from the federal government and Canadian universities played substantial roles as Coordinating Lead Authors, Lead Authors and Review Editors. In the past, funding to support IPCC authors has been provided through the CCAF. With these funds having ended in 2004, EC has assumed the lead financial responsibility for supporting Canadian experts involved in the AR4, although other government departments have also contributed. Canadian experts have also participated in other international expert meetings, including a meeting on greenhouse gas inventories in Helsinki in 2008 and another on Managed land Proxy in Brazil in 2009. The Canadian IPCC Secretariat is funded by EC, and located within the EC-ASAI group referred to above.

Three new GoC reports have provided information on climate science assessment. Two are part of a CO2/Climate Report series that provide regular updates in new developments on climate change science. The first, 2003-2005 Science Review: A Synthesis of New Research Developments, was published in hard copy and made available on-line in 2006. The second, 2006-2008 Science Review: A Synthesis of New Research Developments, was ready for publication and release by the end of 2009. The third report is an updated report on Frequently Asked Questions about the Science of Climate Change was also published in hard-copy in 2008, and made available on the ASAI website.

# References

## Websites

ArcticNet.
http://www.arcticnet.ulaval.ca/

BIOCAP Canada Foundation.
http://www.biocap.ca/

Canadian Carbon Program:
http://www.fluxnet-canada.ca/

Canadian Arctic Shelf Exchange Study
http://www.cases.quebec-ocean.ulaval.ca/

Canadian Centre for Climate Modelling and Analysis (CCCma).
http://www.cccma.bc.ec.gc.ca/

Canadian Climate Change Scenarios Network.
http://www.cccsn.ca/

Canadian Cryospheric Information Network (CCIN).
http://www.ccin.ca

Canadian Foundation for Climate and Atmospheric Sciences (CFCAS).
http://www.cfcas.org/

Canadian Global Coupled Climate Carbon Model (CGC3M) Network.
http://www.geog.mcgill.ca/CGC3M/webpage.htm

Canadian Regional Climate Modelling (CRCM) Network.
http://www.mrcc.uqam.ca/E_v/index_e.html

Carbon Budget Model of the Canadian Forest Sector CBM-CFS3:
http://carbon.cfs.nrcan.gc.ca/CBM-CFS3_e.html

Climate System History and Dynamics (CSHD) Network.
http://www.atmosp.physics.utoronto.ca/CSHD/cshd.html

CRYosphere SYStem in Canada (CRYSYS) Project Website.
http://www.crysys.ca

Ecological Monitoring and Assessment Network (EMAN-North) for Northern Canada.
http://www.emannorth.ca/

Canadian Ice Service.
http://ice-glaces.ec.gc.ca

Environment Canada Climate Trends and Variations Bulletin,
http://www.msc-smc.ec.gc.ca/ccrm/bulletin/

Modelling Clouds and Climate (MOC2) Network.
http://www.eos.ubc.ca/research/moc2/

Modelling of Global Chemistry for Climate (GCC) Project.
http://www.atmosp.physics.utoronto.ca/MAM/home.html

Canada Centre for Remote Sensing (CCRS).
http://www.ccrs.nrcan.gc.ca/

Natural Sciences and Engineering Research Council of Canada (NSERC).
http://www.nserc.ca/

## Major Reports

Canadian Forestry Service. 2009. Evaluation Of The Canadian Forest Service Climate Change Program.
http://nrcan.gc.ca/evaluation/reprap/2009/cfscc-ccscf-eng.php

Council of Science (ICSU) and the World Meteorological Organisation (WMO). International Polar Year (IPY) 2007-2008.
http://www.ipy.org

Environment Canada. 2006. An Introduction to Climate Change – A Canadian Perspective.
http://www.msc-smc.ec.gc.ca/education/scienceofclimatechange/understanding/icc/index_e.html

Environment Canada. 2008. Frequently Asked Questions about the Science of Climate Change: 2008 Update.
http://www.msc.ec.gc.ca/education/scienceofclimatechange/understanding/FAQ/index_e.html

Government of Canada. 2008. The Canadian National Report on Systematic Observations for Climate - National Activities with Respect to the Global Climate Observing System (GCOS) Implementation Plan.
http://unfccc.int/files/methods_and_science/research_and_systematic_observation/application/pdf/canada.pdf

Hengeveld,H., Braithwaite,L.,, Desjardins,R., Gorjup,J. and Hall,P. (eds). 2008. Enhancement of Greenhouse Gas Sinks: A Canadian Science Assessment. PERD POL 6.2.1 Final Report. Environment Canada, Ottawa, 98pp.

Janzen, H.H., Desjardins, R.L., Rochette,P., Boehm, and Worth,D. (Eds). 2008. Better Farming, Better Air: A scientific analysis of farming practice and greenhouse gases in Canada. Publications Section, Agriculture and Agri-Food Canada, Ottawa, Ontario K1A 0C5
http://www.agr.gc.ca/nlwis-snite/

# Chapter 9

# Education, Training and Public Awareness

## 9.1 Introduction

Public education, training, and awareness activities have been a key part of Canada's response to climate change since the late 1990s. Canada's efforts are guided in part by its international obligations. The United Nations Framework Convention on Climate Change (UNFCCC) recognizes the important role of education in the international response to climate change. Article 4(1)(i) indicates that all Parties should "promote and cooperate in education, training and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organization."

Article 6(a) of the UNFCCC expands this requirement, indicating that the Parties shall promote and facilitate:

(i) The development and implementation of educational and public awareness programmes on climate change and its effects;

(ii) Public access to information on climate change and its effects;

(iii) Public participation in addressing climate change and its effects and developing adequate responses; and,

(iv) Training of scientific, technical and managerial personnel.

Canada continues to educate and raise public awareness on the subject of Climate Change, and recognizes that permanently changing behaviours and instilling a low-emissions mindset throughout society is a long-term process. Canada's approach to education, training, and public awareness includes:

- working collaboratively by building networks and partnerships with all levels of government, the private sector, the education system, youth, non-governmental organizations, universities, and others;
- providing tools, support, and advice ;
- increasing the emphasis on measurable objectives, tracking and performance measurement tools; and
- building on successes and lessons learned from past activities.

These approaches are mainly undertaken by two federal departments: Environment Canada (EC) and Natural Resources Canada (NRCan).

## 9.2 Environment Canada

In terms of education (formal and non-formal) and training regarding climate change, Environment Canada focuses primarily on three main areas:

- promoting system change within formal education to strengthen ecological literacy of Canadians, for example by facilitating educator's access to quality learning resources;
- supporting federal consumer engagement programs that encourage Canadians towards specific actions or purchases (such as retiring their old vehicles); and,
- providing support for community based initiatives that engage individuals in environmental actions and behaviours where they live.

To achieve the above, the department uses a variety of venues including, but not limited to, websites, videoconferencing, teacher training, interactive student projects, and community funding programs. Some of these venues have a broad reach such as to all Canadians, whereas others are targeted towards very specific groups such as teachers. Regardless of the approach used, the ultimate goal is to raise climate change awareness while changing behaviour toward a sustainable lifestyle.

### 9.2.1 Websites

Environment Canada's website provides up-to-date resources, information and ideas on climate change, as well as approaches that enable individual Canadians to be part of the solution.

**Take Action for the Environment** - Environment Canada maintains the "Take Action for the Environment" website (http://www.ec.gc.ca/education) which is the most comprehensive source of environmental tips provided by the Government of Canada.

With over 200 web pages of advice on how Canadians can reduce their impact on the environment, the site is organized into such sections as "What you Can Do" and "Educational Resources." Canadians can learn how to make their home more energy efficient, reduce the amount of water used in gardening, and much more. Educators can find lesson plans for a variety of student ages and grades, many of which are about climate change. Additionally, in terms of school operations, there are also tips such as how to establish a "no idling" program and how to best use natural light in schools. The Take Action website received over 150,000 visits in 2008.

### 9.2.2 Retire Your Ride Program

The "Retire Your Ride" four-year program (http://www.retireyourride.ca) helps Canadians recycle their older, higher-polluting vehicles and make sustainable transportation choices, leading to reduced air pollution and greenhouse gas emissions. The program is being delivered by the Clean Air Foundation - a national not-for-profit organization using a network of local delivery organizations, incentive partners, and recyclers.

The program includes a strong educational component to increase older vehicle owners' awareness and understanding of the environmental impacts of their vehicles and to encourage more environmentally-friendly transportation choices.

A national promotional campaign is being delivered by the Clean Air Foundation and participating local organizations. It is supported by a program website and many outreach activities. In addition, the Biosphère Environment Museum in Montreal, which is part of Environment Canada, is creating three high-profile interactive exhibits related to the impact of older vehicles on the environment. The Canadian Urban Transit Association is also developing a public awareness campaign using bus posters to encourage participation in the Retire your Ride program. The Retire Your Ride program ensures that all retired cars are recycled in an environmentally sound way. Vehicle recyclers participating in the program are required to comply with a national Code of Practice to ensure that high standards are met during the recycling process. Free customized training is being provided to participating recyclers to ensure they have the knowledge, skills, and ability to conform to the Code.

### 9.2.3 Environment Canada's Biosphère

The Biosphère (http://biosphere.ec.gc.ca) is an environment museum in Montreal which features exhibitions, guided tours, activities, and animated programming. Visitors can explore and learn about the environmental issues facing our planet, including climate change and air quality.

In regards to climate change in particular, the Biosphère has developed three unique and innovative educational programs that aim to inform Canadians on the importance of reducing their greenhouse gas emissions, and to encourage them to do their part to protecting the environment.

**Climate Change and Clean Air Videos** – Since 2007, the Biosphère has developed a series of thematic videos to reach young people in schools across Canada. The Biosphère experts use multimedia technologies to literally enter classrooms without a physical presence. Using these methods, students and their respective classes can talk directly to the specialists at the Biosphère, view live presentations and activities on climate change, and ask questions about how greenhouse gases are formed, and what students can do to minimize them. Approximately 7,000 students have learned about climate change and air quality issues through educational activities presented via video, or in some cases, through presentations made on-site in schools. Schools in British Columbia, Alberta, Manitoba, Ontario, Nova Scotia, New Brunswick, Newfoundland, and Quebec have been visited, and more are slated to be visited for the 2009/2010 school year.

**X-treme Weather Film** – This film provides examples of extreme weather in the world and in Canada, its impact and link with climate, change and how to protect ourselves. Extreme meteorological events are a natural part of our climate. However, with the global warming of our planet, scientists predict an increase in their frequency and intensity. In Canada, we experience many types of extreme weather events. When they hit our country, the impact can be sudden and can threaten lives and property. It's important to prepare for them and know how to protect ourselves. The film makes recommendations on how to reduce the impact of extreme weather events.

**U-TURN Toward Sustainable Transportation** – This exhibition looks at the impact that personal vehicles have on the environment and public health, and also looks at alternative forms of transportation. This large installation, with its contemporary, non-traditional and avant-garde design, casts a new, fresh and probing light on this social phenomenon. The exposition will be presented at the Biosphère throughout the summers of 2009, 2010, and 2011. A traveling version will tour Canada beginning in the fall of 2009.

U-TURN Toward Sustainable Transportation is designed to encourage visitors to opt for greener forms of transportation by increasing their awareness of the im-

pact that personal vehicles have on the environment and public health. Four interactive zones are set up around a dissected automobile, half of the parts of which are spread out to help visitors better understand the ecological footprint of a car. The car chosen, a 1995 Ford Taurus, is one of the most popular models from the period to which Canada's vehicle recycling program, **Retire Your Ride**, applies. Visitors will also be able to find information on this program.

### 9.2.4 The EcoAction Community Funding Program

Environment Canada's EcoAction Community Funding Program provides financial support to community-based, non-profit organizations for projects that have measurable, positive impacts on the environment. The Program encourages action-focused projects that will protect, rehabilitate or enhance the natural environment. It also supports projects that build the capacity of communities to increase knowledge and skills as well as change attitudes and behaviours so that these activities may be sustained into the future. In keeping with Environment Canada's national environmental priorities, the Program supports projects that address the following four themes:

**Clean air** – reducing air emissions that contribute to air pollutants

**Clean water** – diverting and reducing substances that negatively affect water quality or focusing on water conservation and efficiency

**Climate change** – reducing greenhouse gas emissions that contribute to climate change

**Nature** – protecting wildlife and plants, and protecting and improving the habitat where they live

More information is available at http://www.ec.gc.ca/ecoaction/.

Since 2007, this program has supported 142 projects which dealt with climate change. Some examples include:

#### Managing Water Resources in A Climate Changed World: An Annapolis Pilot Project

*Clean Annapolis River Project*

The changing climate is likely to result in more severe rainstorms. The Clean Annapolis River Project will develop a number of tools that will allow for more efficient water management practices, including the capture of rainwater and the creation of water gardens and other similar features to manage the overflow of rain. This project will use clean water as a natural filter method while enhancing natural ecosystems.

#### Community Trees Program

*Youth Environmental Society*

Thousands of acres of forest in the Preston area were destroyed by Hurricane Juan and a recent forest fire, resulting in the loss of trees and wildlife habitat. The Youth Environmental Society's Community Trees Program will see the youth of the Preston area plant over 20,000 tree seedlings in the areas affected by the hurricane and forest fire. Local residents will also receive education on how to properly burn their wood, resulting in a cleaner, safer and more effective use of woodstoves that will lessen the impact on climate change.

#### The Children's Garden and Biodiversity Center

*Bathurst Sustainable Development*

When children are taught at a young age how their actions affect the earth, they are better equipped to make more environmentally sound choices and perhaps influence their parents' decisions. Bathurst Sustainable Development will provide indoor/outdoor hands-on learning to one English and one French elementary school. Sixteen 30-minute learning modules will instruct children about the impacts of climate change on wildlife, biodiversity and habitat. A children's garden and outdoor biodiversity learning centre will show how everyday actions can help reduce one's effects on climate change.

#### Water, Energy & Climate Change

*Cape Jourimain Nature Centre Inc.*

The need for action on climate change is clearer to the public every day, yet people are often not sure about exactly how they can help. Cape Jourimain Nature Centre's Water, Energy & Climate Change project will provide teachers with tools and resources to provide hands-on experience to youth. The Centre will expand on its existing education programs on water, energy efficiency, alternative technologies and climate change, showing youth how to take action at school and at home.

#### Helping familes to adapt to climate change

*Groupe Littoral et vie*

New Brunswick's long coastline area is particularly vulnerable to the impacts of climate change. Groupe Littoral et VieŚs Helping Families Adapt to Climate

Change program will involve 10 New Brunswick households. These families will participate in workshops aimed at getting families thinking of climate change risks in the Dieppe area and at creating strategies to prevent property damage.

### Biodiversity and Benthics: Developing Freshwater Invertebrate Education Modules for Public Schools

*Hammond River Angling Association*

The invertebrate population directly reflects the quality of the aquatic habitat and can also be affected by pollution and climate change. The Hammond River Angling Association will develop two educational units to add to its Discovering Watershed Ecosystems program. This program will be delivered to approximately 70 middle and high school classes, with students learning how to create better water resources through managing negative influences on watershed populations such as invertebrates.

### 'Our Plants and Climate Change' - Plant Watch Newfoundland and Labrador School Program

*Memorial University of Newfoundland Botanical Garden Inc.*

Climate change is one of the most serious long-term threats to our planet. Memorial University of Newfoundland Botanical Garden's Plant Watch school program will link environmental issues to real-life issues, encouraging students to become life-long learners and citizen-scientists. A teacher's resource kit (also available on line) will be developed that will include hands-on activities, lesson plans, and posters for grades primary to 12, with the goal of reaching 45,000 students across Newfoundland and Labrador to stress the significance of climate change on plant populations.

### Youth and Community Action to Improve Watershed Health and Reduce Climate Change

*Friends of the Rouge Watershed*

This project will expand and reconnect designated ecologically significant areas and wildlife habitat. Volunteers will be trained to plant 50,000 native trees, 20,000 native wildflowers and 200 kg of native tree and wildflower seed on priority Rouge Park restoration sites. Through community presentations, commitments and energy audits, 2,000 students and community volunteers will reduce greenhouse gas emissions by approximately 1,000 tonnes per year. Educational materials will be distributed in four different languages to educate new Canadians on activities that will help reduce their carbon footprint.

### Creation Care DVD and Resource Packet

*Mennonite Central Committee Ontario*

This project will provide education and outreach on climate change to approximately 2500 members of Mennonite faith communities across Ontario. An educational DVD and an accompanying resource package will be created to provide information on activities currently used by other faith communities to reduce their carbon emissions. This project is expected to result in 10 commitments for energy audits and retrofits, 10 commitments to install solar photovoltaic systems, and 50 commitments to participate in a community-supported agriculture scheme. This project is expected to result in a 2,577-tonne reduction in greenhouse gas emissions.

### BowValleyClimate Kids

*Biosphere Institute of the Bow Valley*

The Bow Valley Climate Kids project will provide six teams of local youth with professionally led workshops for writing, directing and editing their own climate change videos within the Bow Valley. Youth teams (including two teams of First Nations youth) will publicly showcase their completed videos to bring attention to climate change and its local impacts. The films will encourage community and individual commitment to action on climate change through pledges to reduce waste, improve water quality, reduce vehicle use and conserve energy.

### The West Central Cycling Program

*West End Cultural Centre*

The West Central Cycling Program is a West End Cultural Centre initiative for increasing environmental awareness within Winnipeg's West Central and Spence neighborhoods and for providing opportunities for community action against air pollution and climate change. The program will work with local cycling groups to promote cycling as a mode of transport for people living in and travelling to these neighborhoods. In addition, the Centre will encourage its audiences to cycle to the Centre's 180 annual cultural events through the installation of 30 secure neighbourhood bicycle racks.

### PlantWatch Saskatchewan

*Nature Saskatchewan*

This project will give "citizen scientists" the opportunity to contribute to knowledge on changes in the natural environment by watching plants bloom. Volunteers will be asked to record information on 20

Saskatchewan plant species; this information will include data such as first bloom, sun exposure and weather conditions. Upon request, the public will also be sent PlantWatch information (e.g. newsletters, brochures, posters, booklets) on the effects of climate change and simple ways to reduce greenhouse gases. Presentations on PlantWatch Saskatchewan will also be delivered through Nature Saskatchewan meetings, trade shows, schools, youth groups and nature societies.

### Integrating Carbon Sequestration and Conservation Goals on Conserved Forest Lands

*Galiano Conservancy Association*

The Galiano Conservancy Association is working to restore provincially and globally endangered coastal Douglas Fir ecosystems on Galiano Island. Restoration efforts undertaken will increase carbon sequestration on the site. This will help reduce the impacts of climate change. Restoration will also increase biodiversity, improve ecosystem health and enhance the site's ability to adapt to the impacts of a changing climate.

### High School Climate Challenge

*Clean Air Champions*

Fourteen schools throughout British Columbia will take the High School Climate Challenge. This challenge will help educate, inspire and engage students in activities that help reduce climate change impacts. To help significantly reduce institutional greenhouse gas emissions in their schools, youth will receive tools, training and mentorship. Clean Air Champions and university students will help inspire and advise the students. The project will also use a recently created online greenhouse gas audit tool calculator to enter data and produce graphic reports.

### Education for Sustainable Living: Beyond Recycling

*Wildsight*

Education for Sustainable Living is a school-based environmental education program for grades 5-7. It helps support students and teachers in understanding and addressing sustainability challenges in a world facing increased climate change and environmental degradation. To encourage place-based learning, the project links school-based education with community stewardship initiatives. Participants will engage in activities in their homes, schools and communities. The activities will be designed for positive and measurable results that will inspire and empower positive environmental change.

### Accelerating to 0

*Community Energy Association*

Accelerating to 0 focuses on three key topics: land-use planning, transportation and buildings. A series of workshops will be held with the goal of identifying specific policy and regulatory measures required to reduce local greenhouse gas emissions. The project will work on a regional scale, collaboratively with key urban planners and elected officials, to build capacity and deploy high-impact policies, plans and regulations that address climate change and its impacts.

### Climate Change and Clean Air Forum

*T'Sou-ke Nation*

The Climate Change and Clean Air Forum is a project of the T'Sou-ke First Nation, Vancouver Island. The project will highlight the impacts of climate change, demonstrate renewable energy opportunities and encourage and build capacity amongst a wide range of people–especially Aboriginal peoples on southern Vancouver Island. It will build on the awareness of renewable energy opportunities and take action around clean air and climate change within the T'Sou-ke community and other surrounding communities.

### Stanley Park's Kids for Conservation Skills Training Project

*Stanley Park Ecology Society*

Through inspiration and education, the Stanley Park Ecological Society is helping children become environmental stewards. Stanley Park's Kids for Conservation, a skills training project, is empowering youth to take action. The project focuses on conservation initiatives that enhance ecosystem health and mitigate climate change impacts. The Society will provide practical science and technical skills, resources and leadership training to build the capacity of young environmental stewards.

### Young Northerners Take Action

*Greenthink – A Yukon project of the Tides Canada Initiative Society*

Young Northerners Take Action is a curriculum-linked project designed to get people interested and involved in reducing their impact on the environment, especially activities that reduce the impacts of climate change. Through workshops, young northerners will find out about climate change and what they can do to reduce climate change impacts. The workshops focus on helping students take action at school, at home and while travelling. The commitments students make will

be posted on a website. The website will help them chart their progress on their "take action" projects.

### C-Vert

*Fondation Stephen R. Bronfman*

This project will incite 60 young people, ages 14 to 16, to take concrete action on environmental priorities they will have identified themselves in order to better link their behaviour with climate change. The young people will then share their knowledge and actions directly within their communities, located in three boroughs of Montréal.

### Designing Net-Zero Energy Communities for a Liveable Future

*Falls Brook Centre*

The Falls Brook Centre is a non-profit, environmentally focused, community development organization and training facility in Carleton County, New Brunswick (http://fallsbrookcentre.ca). The Centre has four program areas: Organic Agriculture, Forest Stewardship, Appropriate Technology, and Community Development. Working within a local rural community and across the Maritimes, Falls Brook Centre brings on the ground practical application and implementation of sustainable development.

The Net-Zero project involved several experts and local people hosting workshops that integrated sustainable development planning approaches with energy conservation-oriented design techniques. The workshop series helped to build the capacity of individuals and communities interested in re-designing their local environments to achieve a net-zero energy consumption future, toward decreasing the impact of climate change. The workshops addressed two key issues: landscape level design, and natural building and renewable energy techniques.

### Two Key Climate Change Programs

*New Brunswick Lung Association*

The New Brunswick Lung Association (www.nb.lung.ca) is committed to improving respiratory health through research, education and outreach. The Association's work addresses the issues of indoor and outdoor air quality. It operates many programs that encourage individuals, businesses and other organizations to improve their energy efficiency in order to reduce polluting emissions and greenhouse gasses.

For example, the S.I.M.P.L.E program teaches high school students to educate their peers about how to use cars in a more energy-efficient manner through **S**peed control, **I**dling prevention, **M**atching vehicle to their needs, correct **P**ressure in tires, **L**eaving their cars at home, and **E**ngine tune-up.

Additionally, the New Brunswick Lung Association, in cooperation with the New Brunswick Department of Family and Community Services and the Healthy Daycare Program, is working with New Brunswick daycares to examine and improve energy efficiency and to improve the indoor and outdoor environment of these facilities.

These programs translate complicated environmental issues into plain language and easy-to-carry-out actions. The Lung Association also aims to provide education, communications, and awareness projects and initiatives for people where they live, work, and play.

### Antigonish Sustainable Development Adopters Project

*Antigonish Sustainable Development*

Antigonish Sustainable Development seeks to proactively promote, further, and influence the environmental, economic, cultural and social elements of sustainability initiatives in the Antigonish region. Their mandate is to move the community towards sustainability while improving the health, well-being, infrastructure, and overall quality of life.

Antigonish Sustainable Development Project worked to develop sustainability action plans for businesses, organizations, and institutions through a capacity building model known as the "Adoption Process." They also built community capacity for sustainable initiatives in the Antigonish area, providing tools and solutions to the community at-large for becoming more sustainable. Forty businesses have signed commitments to continue with efforts to green their enterprise.

### Stratford in Action: Sharing Best Practices to Reduce Our Carbon Footprint

*Environmental Coalition of Prince Edward Island*

ECO-P.E.I. is a community-based action group formed in 1988. Their goal is to work in partnership with others in order to understand and improve the Island environment. Their work centres on education, advocacy and action with members who have a concern for their own health, the health of their families, and the health of the ecosystem.

The Environmental Coalition of Prince Edward Island will be providing residents of Stratford late in 2009 with an on-line Climate Change Action Resource Book. This will describe actions they have taken to reduce their carbon footprint through re-examining their transportation, electricity and water use patterns. Rec-

ommended actions range from home heating with a groundwater pump to using a clothesline.

The goal is for residents to use some of the examples to reduce their own carbon footprint and to be educated about environmentally-friendly practices that are easy to adopt and implement. It will be available free of charge on Stratford's website at http://www.town.stratford.pe.ca and will be used to develop future workshops aimed at engaging residents on carbon reduction.

### Giving Businesses Greener Futures

*Conservation Corps of Newfoundland and Labrador (CCNL)*

The Conservation Corps of Newfoundland and Labrador (CCNL) is a not-for-profit organization dedicated to providing youth with training and employment in environmental and cultural heritage conservation (http://www.conservationcorps.nf.ca). Focusing on environmental and cultural projects and resources has enabled CCNL to provide strong employment training as well as a stronger connection for young people to their communities and to the natural world, encouraging youth to be more active in the development and conservation of the local environment and cultural resources.

In 2006, the CCNL developed a Greener Futures toolkit to assist entrepreneurs and businesses in reducing their environmental impact. The toolkit includes background reading material, presentation slides and speaker's notes, case studies, information sheets, and activities, all designed to help entrepreneurs transition to a more environmentally-friendly business.

The current project involves expanding and updating the toolkit to include recent rebates and incentives that were not available when the materials were first developed. Additionally, the current project involves marketing and promoting the program again to the business community starting in the fall of 2009. The toolkit will be marketed again across Newfoundland and Labrador through advertising, regional workshops, one-on-one consultations, and a website.

### Ontario Hospitals Healing the Environment

*Greenhouse Gas and Air Emissions Challenge*

Hospitals are among the most energy-intensive buildings in Canadian communities. With so much potential energy savings, Ontario hospitals are being challenged to reduce their greenhouse gas emissions and the harmful air emissions they generate.

This project brought together 15 facility managers to learn more about energy efficiency and new technologies, and to get the technical guidance and tools they needed to meet their environmental goals. Twenty-five hospitals participated in the project and 44 greenhouse gas reduction strategies were identified by participating hospitals. Approximately 7,783 tonnes of greenhouse gas emissions were reduced by hospitals participating in the project through a variety of ways, such as window and lighting retrofits.

Today, the project has evolved and now aims to reach all hospital employees so they too can do their part in helping to "heal the environment." Other provinces have also shown an interest in implementing similar projects.

### Green Building 101 Workshops

*Lighthouse Sustainable Building Centre*

As part of a 'build smart' movement, Canadians are hungry for ways to make homes and workplaces more energy efficient and healthier. For tips on how to get started, people can go to the "Growing Green Buildings" workshops and seminars hosted by the Light House Sustainable Building Centre in Vancouver. More information is available at http://www.sustainablebuildingcentre.com/home_services.

Participants gain a general understanding of green design ideas, issues and processes, develop a set of personal green goals for their home, and leave with a practical resource workbook. "Guest Expert Seminars" featuring guest experts trained in the fields of architecture, contracting, and real estate are also available.

Participants who received training or education were asked to share measurable improvements in their homes and workplaces based on five key areas including: energy, water, material savings, hazardous materials averted, and greenhouse gas (GHG) emission reductions. It was estimated that subsequent home upgrades saved an estimated 2.7 million kWh of electricity and over 500 tonnes of greenhouse gas emissions. Nearly 200 participants pledged to obtain a home energy assessment and 336 participants committed to adopting GHG reducing behaviours. 582 people toured the Light House or another green building. In total, the Light House and booths at public events received 2,789 requests for information.

### SFU Local Food Project & Campus Food Miles Reduction Action Project

*Simon Fraser University*

Simon Fraser University students believe that consumers can make smarter choices by buying local food, which in turn, also helps to decrease greenhouse gas emissions. With this in mind, students launched a plan

to help 24,000 students and staff to buy local. Interest in sustainable food was growing on campus but local food options were simply not made available.

The university is located on Burnaby Mountain, and therefore is a self-contained campus; this meant food was purchased through one source – the campus cafeteria. Students and community environmental groups launched the SFU Local Food Project (http://www.sfu.ca/) which aims to: raise awareness of the benefits of local food, encourage and support local food production and distribution projects on campus (e.g., farmers' markets, community gardening), and increase the amount of local food available on campus. Reducing transportation distances can have a positive impact on greenhouse gas emissions. However, it is important to note that transportation-related emissions are only one of several factors affecting the overall carbon intensity of agricultural production, and reducing transportation distances will not necessarily result in a net reduction in greenhouse gas emissions.

The Food Miles Reduction plan organizes fun community-based events. The Local Food information kit provides food strategies and is viewed as a valuable resource for local-food advocates. Additionally, the kit includes such things as a food guide on where to buy local foods. The Local Food project increased the amount of local food available on campus by increasing access to more local foods through two other sources.

Throughout this project, 7,000 people attended the events and 4,000 requests for information were received by the organizers.

### 9.2.5 Report on the Science of Climate Change – Questions and Answers for Canadians

Environment Canada produces products to help inform the public about the science of climate change. For example, an updated version of the "Frequently Asked Questions about the Science of Climate Change" report was published by Environment Canada's Atmospheric Science Assessment and Integration group in 2008. The original version of this report was published in 2002 to help address public confusion about many aspects of climate change science. The report is intended primarily as a resource for those engaged in outreach on climate change, to provide them with a scientifically robust set of responses to questions they are most likely to be asked by members of the public. The 2008 update has revised the content of the original report to reflect current scientific understanding as shown in, principally, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, released in 2007. The 2008 update has deleted a number of questions that were in the original report that are no longer relevant, and several new questions were added to address current issues in the science of climate change.

The report provides both simple responses, as well as more detailed technical explanations to each question, and as such will serve a wide variety of readers. The report has been well received over the years, with the web version of the original report logging approximately 22,000 hits in 2007. An English version of the updated report is available on Environment Canada's website at http://www.eg.gc.ca/scitech/default.asp?lang=En&n=2A953C90-1, while a French version is available at http://www.ec.gc.ca/scitech/default.asp?lang=Fr&n=2A953C90-1.

### 9.2.6 Working with Partners

**Climate Change Education – Canadian National Scout Jamboree 2007** – Environment Canada has worked with Scouts Canada to provide forecasting services and environmental education opportunities at Scout jamborees (large camps with between 2,000 and 10,000 youth attendees that occur every two to four years) since 1991. The 2007 national Jamboree near St. Sauveur, Quebec brought together almost 8,000 Scouts and adults from across Canada and around the world for a week-long camp celebrating the 100th anniversary of Scouting.

Using several different activities, Environment Canada staff helped Scouts learn about climate change mitigation and adaptation. In a "Salmon Life Cycle" activity, Scouts acted as salmon through an obstacle course mirroring the challenges salmon face during their migratory life cycle. Scout leaders participated by acting as predators (human, animal, or climatic) but despite those who made it through successfully, Scouts learned that only a fraction of salmon in the wild survive the real trip. The role of human intervention and climate change effects on salmon and their habitat on the Atlantic and Pacific coasts was highlighted.

To demonstrate the challenges of alternative energy, there were 3 hands-on activities for the Scouts to build and try: sailcars, a fuel cell car, and solar ovens. The sailcars demonstrated wind power; the children designed and built small paper and wooden sailcars (incorporating physics and engineering qualities), and gravitational energy (ramp) or Scout energy (breath) was harnessed when wind was not available.

Using a model solar and/or fuel cell, Scouts took voltage meter readings and learned the potential and limitations of these forms of alternative energy.

Solar ovens were the experiential favourite; personal-size pizza boxes, foil, black paper and plas-

tic wrap were used to construct solar ovens that could be used to cook a camp favorite: smores. This helped demonstrate an alternative form of energy possible for Scout cooking.

The Scouts were also asked to graph the distance and mode they traveled to get to camp to calculate their potential carbon offsets. Using two interactive models Scouts also tested different energy choices. (http://passion4action.com/tools/interactive-exhibits)

**Climate Change Education at Teachers Day – Canadian Meteorological and Oceanographic Society 2009 Congress** – The Meteorological and Oceanographic community encourages and promotes education not only to the science community but also to teachers and in turn, students. The grade 10 curriculum in British Columbia was changed in 2008 to include units in meteorology, specifically energy transfer. Presenters were encouraged to focus on this theme for Teachers Day, which was an opportunity for teachers, especially science teachers, to see and interact with the larger science community.

Two of the most effective presentations were on the topic of climate change, one from the energy perspective, and one from the oceans perspective. The Pembina Institute gave an integrated presentation on energy and climate change. This was an interactive session where teachers were asked to participate in activities using eCards developed by Pembina (http://www.greenlearning.ca/ecards), and they spoke about the EnerAction program they promote for grades 4 to 7 (http://www.greenlearning.ca/eneraction). Additionally, another presentation given by the Banfield Marine Station (http://www.bms.bc.ca/pubed.html) engaged the teachers in experiential activities about water temperature, the effect of ice melting, and changes to ocean biodiversity. Climate change education was demonstrated by showing the teachers the effects of a melting popsicle or by mixing salt water and fresh water.

**The United Nations Decade of Education for Sustainable Development** – Environment Canada has supported the UN Decade for Education for Sustainable Development, through two main networks: The Provincial / Territorial Education for Sustainable Development Working Groups and ESD Canada, through Learning for a Sustainable Future; and The United Nations Regional Centres of Expertise (RCE). The work undertaken by both networks, in part, pertains to climate change.

In partnership with the Province of Manitoba and a non-governmental organization, Learning for a Sustainable Future (http://lsf-lst.ca), 10 working groups were created as well as a national advisory council, known as ESD Canada. Working group members include business, communities, educators, students, and governments across Canada. The ESD working groups conduct several activities, including develop websites to share environmental and other information, influence provincial curricula regarding sustainable development, and hold youth workshops on sustainable development. For example, through the combined work of LSF and the working group in Ontario, they were able to participate in, and influence, the outcome of the Roberta Bondar Task Force in terms of incorporating environmental education into the school curriculum. In addition, the Youth Action Forums encourage youth to examine climate change issues and take on action projects at school that interest them, for example, performing an energy audit at school.

The UN Regional Centres of Expertise (RCE) Network was created by the UN University (http://www.ias.unu.edu) as its contribution to the UN Decade for Education for Sustainable Development. The purpose of the international network is to undertake research to better understand and to advance education for sustainable development, which includes the subject of climate change. To date, there are 62 RCEs throughout the world. There are four RCEs in Canada, which cover regions in: Toronto, Greater Sudbury, Montreal, and Saskatchewan. Partners include business, community groups, educators, scientists, museums, governments, and more.

From May 13 to 15, 2009 the United Nations University and the global Regional Centres of Expertise held their 4th World Conference in Montreal, Canada for over 150 international delegates. Environment Canada played a key role in hosting this event and also sits as a member of the Montreal RCE team. At this conference, the Saskatchewan RCE provided a workshop on Climate Change to participants from over 20 countries. The interactive workshop was an opportunity to engage the international community in identifying the challenges ahead and sharing best practices regarding climate change. The ultimate goal is to work together, on a national and international level, to use education and training to raise public awareness and change behaviour toward sustainable practices.

## 9.2.7 Other Activities:

### Environmental Careers Organization (ECO) Canada: Greenhouse Gas Practitioner Certification

As climate change continues to make headlines and companies across the globe strive to reduce their greenhouse gas emissions, the demand for professionals capable of demonstrating nationally and internationally

recognized skills in this sector becomes even greater. In response to this demand, the Environmental Careers Organization (ECO) Canada (http://www.eco.ca) and its certification body, the Canadian Environmental Certification Approval Board (CECAB) is in the process of developing a national certification program for GHG verifiers, validators and practitioners. To date, GHG experts and key informants have drafted a basic National Occupational Standards (NOS) for the sector which defines the skill set required to work within Canada's GHG sector.

To assist in the development of the NOS and to provide operational direction, the Greenhouse Gas Project is driven by three committees. These include a national steering committee that oversees the project as a whole and two working groups to provide operational direction: a certification working group, and a NOS working group. These committees oversee the project on a step-by-step level and provide input as required for certification development and NOS development. It is anticipated that the NOS will be finalized by the end of 2009.

Additionally, ECO Canada has a branch that deals with aboriginal human resource issues known as Building Environmental Aboriginal Human Resources (BEAHR) (http://www.beahr.com). BEAHR conducts research on environmental training needs, develops national occupational standards and curriculum where gaps exist, and administers the delivery of community-based training programs for Aboriginal learners (including First Nations, Métis, and Inuit). Together, ECO Canada and BEAHR have developed a number of training and education programs designed to provide environmental skills and awareness to the aboriginal community. Components of all these resources can relate back to climate change issues.

The Local Environmental Coordinator (LEC) program is an example. The curriculum was developed and approved between 2007 and 2008. Once trainers have been licensed to teach it, then the first group of Aboriginal students will be able to learn basic knowledge and skills necessary for them to successfully coordinate environmental activities within their community. A LEC assists in protecting and improving the quality of the environment in his or her community. The coordinator contributes to monitoring local environmental surroundings and makes recommendations needed to respond appropriately to changing environmental conditions. The level of responsibility and range of duties are directly proportional to the size and needs of the community in which the coordinator is working.

The Sudbury Climate Change Consortium Partnership - Numerous agencies and organizations with a focus on one or more aspects of Climate Change Adaptation and Risk Management currently exist in Greater Sudbury. Most are very active within their own areas of interest, but much work is being done in virtual isolation. Opportunities for intergroup communication, information exchange and collaboration are vitally important.

To that end, a Sudbury Climate Change Consortium Partnership is in the formative stages to bridge these gaps enabling the partners to work together collaboratively for the benefit of their watershed residents, water resources, and infrastructure. The Nickel District Conservation Authority (NDCA) has taken the lead in this community action.

The Climate Change Consortium Partnership will enable information sharing, wider participation on group activities, and heightened public awareness and education on climate change impacts and adaptation strategies in the Nickel District watersheds. Through this partnership, members will also report back to the community on a regular basis. The Sudbury Climate Change Consortium Partnership will have a steering group. Membership is open and new partners will be welcomed.

The Nickel District Conservation Authority (www.nickeldistrict.ca), with direct involvement of their member municipality the City of Greater Sudbury, is well positioned to lead the consortium partnership. A number of key steps will be taken, including a detailed presentation to Greater Sudbury Council at a Strategic Planning session with a focus on climate change adaptation and risk management approaches for the community. The partnership is to be formed and active by the end of 2009.

Considering the position of the City of greater Sudbury as a designated UN Regional Centre of Expertise, the actions and strategies to be implemented by the Sudbury Climate Change Consortium over the next five to ten years can become a global model like the reclamation / re-greening of Sudbury's natural environment throughout the last thirty years.

### Saskatchewan Idle Free Zones

Provincial promotion of idle free zones for schools, public transport, and government vehicles through the Ministries of Environment and Education. 196 Zone signs have been sent to 105 elementary and high schools with posters and information cards. Go Green clubs in schools take leadership in encouraging parents to turn off their cars while waiting to pick up students. Anti-idling stickers are provided for over 5000 government vehicles and 451 idle free zone signs have been directed to 197 government facilities.

## 9.3 Natural Resources Canada

Natural Resources Canada (NRCan) has a mandate to promote the responsible development and use of Canada's resources, with specialization in energy, minerals and metals, forests, and earth sciences. NRCan supports initiatives that promote action on energy efficiency, alternative fuels and renewable energy. These include education, training and public awareness activities in all sectors of the Canadian economy. NRCan's web site provides information on the department and its climate change activities. (http://www.nrcan-rncan.gc.ca/com/index-eng.php)

### 9.3.1 Office of Energy Efficiency (OEE)

Many of NRCan's climate change-related programs are coordinated through the OEE, established in 1998 to be Canada's centre of excellence for energy efficiency and alternative fuels information. Some OEE program highlights are provided in Table 9.1. In addition to programs aimed at the residential, equipment, commercial/institutional, industrial and transportation sectors, the OEE also distributes energy efficiency and alternative energy publications to individuals and organizations.

The OEE gathers and publishes a wide range of energy efficiency data, such as trends in Canadian energy use and the GHG intensity of various energy sources, and makes this information available to public- and private-sector organizations, as well as to the Canadian public. This raw data forms the basis for energy use, energy efficiency, and GHG calculations for climate change studies and reports, as well as for materials intended for the public.

The OEE's energy efficiency and alternative fuels programs are described in depth in Chapter 4, Policies and Measures. Most of the programs include public outreach and education components designed to inform target audiences so that they can make wise construction, purchasing, and retrofitting decisions.

The OEE provides practical energy conservation advice to consumers, school boards, businesses, and institutions, and has links to hundreds of related sites around the world. The OEE is assisted in this work by National Advisory Council on Energy Efficiency.

Informing key decision-makers in government, industry, and the environmental and international communities about Canada's energy conservation and energy efficiency efforts and successes is a major focus of the OEE. Toward this end, the OEE publishes many comprehensive reports which are available online. Other information activities include exhibits, advertising, toll-free telephone lines, conferences, web sites, workshops, training, building design software, and promotional products.

In the commercial/ institutional/ and industrial sectors, the OEE coordinates training in energy management techniques and promotes best practices in energy efficiency through programs designed to engage companies in setting targets for reduced energy use and lowered GHG emissions.

In both the residential and commercial/ institutional/ industrial sectors, the OEE also manages programs that encourage homeowners, businesses and others to switch to energy-efficient equipment (including appliances). The programs support extensive regulations in this area.

The OEE's transportation programs encourage improved energy efficiency of the personal and commercial vehicle stocks and seek to influence driver behaviour, vehicle maintenance practices and fleet management. Extensive educational material is found on the OEE's programs website (http://oee.nrcan.gc.ca/english/).

Outreach activities also target youth as future energy consumers through public information activities that increase awareness of the environmental impact of energy use. An annual art contest for school-aged children that highlights themes related to energy efficiency and the environment is a key outreach activity to engage kids from every province and territory. An Energy and the Environment Activity Book, featuring 10 classroom-ready activities related to energy use and energy conservation, was distributed in February 2009. The Kids' Club website offers parents and teachers educational and fun resources aimed at promoting energy efficiency to our youngest Canadians.

The ecoENERGY Efficiency Initiative features the following OEE programs which contain training or public awareness components:

- ecoENERGY Retrofit offers homeowners, along with smaller businesses and organizations, financial support and information to retrofit their homes, smaller buildings and industrial processes.
- ecoENERGY for Buildings and Houses encourages both the construction and retrofit of more energy-efficient buildings and houses.
- To promote energy efficiency in new buildings, the program offers a number of tools and activities including modelling software, training, information, and access to stakeholder networks and validation of new building designs.
- ecoENERGY for Industry aims to accelerate energy-saving investments and the exchange of best-practices information within Canada's industrial sector.
- Canadian Industry Program for Energy Conservation (CIPEC) training and awareness initiatives encourage energy efficiency to improve industrial productivity, cut costs, and contribute to the government's policy goals. Under CIPEC, more than 15,000 representatives from over 4,500 organizations from across Canada have enrolled in Dollars to $ense Workshops. The one-day workshops are designed to disseminate energy-saving tips to industry representatives so as to benefit their organizations and facilities through lower operating and production costs, an improved competitive position, reduced GHG emissions, increased operational efficiency, and a better work environment.
- ecoENERGY for Fleets focuses on reducing fuel use and greenhouse gas emissions in commercial and institutional fleets through several methods: training and education; sharing of best practices; anti-idling campaigns; and technical demonstrations to identify opportunities for improvements.
- ecoENERGY for Personal Vehicles provides Canadians with helpful tips and decision-making tools on buying, driving and maintaining their vehicles to reduce fuel consumption and greenhouse gas emissions. The program provides novice drivers with resources and information ranging from Auto$mart fuel efficiency instruction to on-line videos and to simple and concise driving tips for fuel efficient driving practices.
- A regulatory agenda, under the authority of the Energy Efficiency Act, will introduce or raise energy efficiency standards for a wide range of energy-using products. Stricter regulations mean that, over time, inefficient products will disappear from the marketplace.
- EnerGuide for Equipment: EnerGuide labels increase public awareness of the link between energy and the environment, and promote the opportunities opened up by energy-efficient technology. The labels, which can be affixed to the product alone or be part of its price label, have a standardized design and provide a measurement of energy performance.
- ENERGY STAR®: The international ENERGY STAR® symbol takes the EnerGuide concept one step further, by identifying for consumers the products that are among the most energy-efficient ones on the market.
- ecoENERGY for Biofuels provides operating incentives, over the period 2008 to 2017, to producers of renewable alternatives to gasoline and diesel.

**Table 9.1: OEE Program Highlights**

### 9.3.2 Canadian Forest Service (CFS)

NRCan's CFS investigates how forests interact with climate and the role they occupy in the issue of climate change. It plays a key role in publishing scientific findings, translating its findings into information relevant to partners, increasing awareness of climate change and its impacts on forests, and developing skilled workers. CFS works with industry, universities, NGOs and other federal and provincial government departments on several aspects of climate change. In its latest national forest strategy, A Vision for Canada's Forests 2008 and Beyond, the Canadian Council of Forest Ministers has identified climate change along with the transformation of the forest sector as the two priorities of national importance for Canada's forest sector.

The CFS generates and shares forest science knowledge that helps increase awareness and understanding of climate change impacts and support the development of climate change mitigation and adaptation strategies for the forest sector. From 2007 to 2009, the CFS produced 127 publications related to climate change and atmospheric influences including 95 peer-reviewed scientific publications (as of July 2009). Two synthesis reports were also released by the CFS during that period:

- Climate change and Canada's forests: from impacts to adaptation. 2009. Williamson, T.B.; Colombo, S.J.; Duinker, P.N.; Gray, P.A.; Hennessey, R.J.; Houle, D.; Johnston, M.H.; Ogden, A.E.; Spittlehouse, D.L. Natural Resources Canada, Canadian Forest Service, Northern Forest Research Centre, Edmonton, Alberta, Sustainable Forest Management Network, University of Alberta, Edmonton, Alberta. 112 p.

- The importance of forest sector adaptation to climate change. 2008. Lemprière, T.C.; Bernier, P.Y.; Carroll, A.L.; Flannigan, M.D.; Gilsenan, R.P.; McKenney, D.W.; Hogg, E.H.; Pedlar, J.H.; Blain, D. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. Information Report NOR-X-416E. 78 p.

These documents summarize our understanding of how a changing climate impacts Canada's forests and forest sector and provide recommendations for adaptation.

CFS has been leading Canadian participation in CarboNA, a joint government-level initiative between Canada, the US and Mexico. CarboNA works to identify continental-scale priority issues and promote collaborative research in areas of common interest and complementary expertise. Its goal is to establish greater cohesion across North America in the fields of carbon pool and greenhouse gas flux dynamics and of carbon related mitigation strategies.

The CFS develops and disseminates predictive models of climate change impacts. These science-based products contribute significantly to raising awareness and educating on climate change impacts and on mitigation and adaptation options. Examples include:

**Canada's Plant Hardiness project** is a web application that maps the potential distribution (size and location of climate habitat) of 130 North American tree species under different climate change scenarios. This online decision support tool receives tens of thousands of unique visitor-hits monthly. It contributes to raising awareness on the impact of climate change on species' climatic envelopes and to developing adaptation options for forest management and individual tree plantings.

**BioSIM** is a software tool for use in forecasting events in the seasonal biology of insect pests. Coupled with process-based phenology models, BioSIM allows for the prediction of changes in outbreaks of a range of pests under different future climate scenarios and helps time the application of pest control substances in forestry, agriculture, and horticulture for optimal results.

**Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)** simulates carbon dynamics of above-ground and below-ground biomass and dead organic matter associated with both stand-level and landscape-level processes. It is used to project the potential impact of climate change, variation in disturbance regime and management activities on the forest carbon budget. An operational-scale version of CFS's CBM-CFS3 is publicly available at http://carbon.cfs.nrcan.gc.ca. Analysts from industry and provincial and territorial resource management agencies can use the model to evaluate the impacts of alternative forest management strategies on carbon emissions and removals.

CFS engages in training researchers and industry personnel on the application of the climate change related models it has developed. From 2007 to 2009, 9 training workshops (total of 220 individuals) were held on the CBM-CFS3 (as of July 2009). Support and training is also provided on other simulation models and decision support tools (e.g., BioSIM).

CFS, in partnership with the Natural Sciences and Engineering Research Council and the Social Science and Humanities Research Council, supports graduate student research through the Graduate Supplement Program. This program allows students to conduct research in collaboration with CFS research centres. The Program has supported 71 graduate students from

2000 to 2009, some of whom have done research related to climate change.

The Canadian Carbon Program (CCP) is a national research network of university and government scientists that started in March 2007, expanding on the scientific contributions of past large-scale field experiments, including the Boreal Ecosystem – Atmosphere Study (BOREAS), Boreal Ecosystem Research and Monitoring Sites (BERMS) and Fluxnet Canada Research Network (FCRN). The CCP has contributed significantly to the advancement of forest carbon cycle science. CFS plays a leading role in CCP with more than 15 researchers from five regional centres contributing to network activities. Since its creation, the CCP/FCRN has supported the training of more than 115 graduate students and postdoctoral fellows.

CFS has been leading Canadian participation in the North American Carbon Program, a US-initiated tri-lateral research program that plans to provide continental-wide estimates and maps of carbon sources and sinks using state-of-the-art approaches. The program involves collaboration of public sector and university-based researchers in Canada, the United States, and Mexico.

### 9.3.3 Earth Sciences Sector

In the Earth Sciences Sector, the Climate Change Impacts and Adaptation Division delivered activities to build awareness and capacity to address adaptation to climate change. There was a change in focus for outreach and capacity building activities over the period of this report, shifting from a broad engagement approach to focus more on specific practitioner and stakeholder groups.

The Division worked closely with the Canadian Council of Professional Engineers and the Canadian Institute of Planners, supporting these two practitioner groups in engaging their members the issue of adaptation to climate change.

In cooperation with the Canadian Climate Impacts and Adaptation Research Network (C-CIARN), which was closed in 2007, the Division published Adapting to Climate Change, an introduction for Canadian Municipalities. This document provides an introduction to the issue for municipal leaders and officials.

Building on the legacy of over 300 research projects funded between 1998 and 2007, the Division published Canada's second national scale assessment of the impacts of and adaptation to climate change in Canada. The document, From Impacts to Adaptation: Canada in a Changing Climate 2007, provides a regional assessment of the latest information on a regional basis. Available in print, CD, and on a website, the document has been distributed to decision-makers, teachers, and academics and has been incorporated into curricula in several university-level courses.

## 9.4 Quebec

### "Action-Climat" Program

The "Action-Climat" Program addresses the needs of non-profit organizations and cooperatives that wish to present awareness and education projects in order to take concrete steps towards reducing greenhouse gas emissions. Nearly twenty community projects have been funded as part of this program.

### Turn off your motor! Program

This Program finances municipalities in support of public awareness campaigns dealing with the adoption of new driving habits.

### The Climate Project – Canada

After having been a major partner in developing a climate change training session organized in April 2008 by The Climate Project – Canada, the Canadian subsidiary of the organization founded by former US vice-president Mr. Al Gore, Quebec granted new assistance in September 2009 to this organization for the installation of its secretariat in Montreal. Total assistance granted: $400,000.

### Global Climate Campaign Secretariat

Quebec financially supports the establishment of the Global Climate Campaign Secretariat in Montreal, an organization dedicated to mobilizing the public for climate change.

### Climate Challenge

In December 2009, Quebec granted $785,000 in financial assistance to the Regroupement national des conseils régionaux de l'environnement du Québec (RNCREQ) to extend its Défi Climat campaign to all of Quebec's regions. The objective of the campaign is to encourage citizens from professional and educational sectors alike to take concrete action in the fight against climate change.

### Retire Your Ride! Program Extension

The Government of Quebec supports the Association québécoise de lutte contre la pollution atmosphérique (AQLPA) on the order of $3 million so the association can extend the federal Retire Your Ride program to increase incentives aimed at making even more attractive the idea of turning in one's vehicle for a sustainable transportation option.

### Carbon Market Training

Training designed for Quebec companies and organizations was developed and is being offered on a regular basis. The training covers all business opportunities in Quebec that are associated with the carbon market, how it works, standards to meet for obtaining credits, project examples, steps required to carry out a project, as well as potential costs and revenues ($3 million).

### Promotion of Public Transit

Subsidies are granted to finance part of the costs incurred by transport organizing authorities to promote public transit ($12 million).

### Promotion of Alternative Means of Transportation to the Automobile

Financial support is offered to non-profit organizations so they can implement education, awareness and promotion initiatives regarding alternative means of transportation to single occupancy vehicles (walking, bike riding, public transit, shared taxi or car pooling).

### Energy Efficiency Awareness Tools

Since 1997, the mission of the Agence de l'efficacité énergétique has been to promote energy efficiency and the development of new energy-efficient technologies for all forms of energy in every sector of activity, including among ministries and public organizations.

### Research Partnership Program for the Reduction and Sequestration of Greenhouse Gases

Investments of $4 million have been made to support targeted research partnerships to consolidate and create teams of researchers who work rigorously to fight climate change.

# Appendix A

# Annexes

## A.1 Selected Common Reporting Format (CRF) Tables

For purposes of consistency, the following CRF tables have been adapted such that emissions/removals of all gases are treated in a similar manner when comparing totals with and without LULUCF.

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gg | | | | | | | | | | | | | | | | | |
| **Energy** | **424490** | **414905** | **429627** | **427716** | **440951** | **452838** | **465050** | **476365** | **485008** | **499244** | **522306** | **518231** | **525272** | **544301** | **537847** | **528781** | **516483** | **550120** |
| Fuel Combustion Activities | 413932 | 403896 | 417402 | 414495 | 427183 | 438277 | 449573 | 460599 | 467582 | 483563 | 506301 | 502595 | 509432 | 527900 | 521951 | 513344 | 500269 | 534174 |
| Energy Industries | 144307 | 143246 | 151876 | 143411 | 146334 | 152285 | 151726 | 159719 | 174928 | 183142 | 195217 | 200791 | 199730 | 204857 | 194914 | 187654 | 179945 | 192613 |
| Manufacturing and Construction | 62488 | 58652 | 57885 | 57593 | 60912 | 61704 | 64425 | 64425 | 60858 | 61078 | 64175 | 59827 | 61842 | 66160 | 66972 | 63928 | 64473 | 71783 |
| Transport | 138377 | 133745 | 137145 | 140231 | 147027 | 150861 | 154542 | 160431 | 163857 | 168015 | 169375 | 167865 | 170107 | 174694 | 180120 | 184081 | 183488 | 191555 |
| Other Sectors | 68760 | 68252 | 70496 | 73260 | 72909 | 73427 | 78880 | 76025 | 67939 | 71327 | 77534 | 74113 | 77753 | 82189 | 79945 | 77682 | 72363 | 78223 |
| Other | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE |
| Fugitive Emissions from Fuels | 10559 | 11010 | 12225 | 13221 | 13768 | 14560 | 15477 | 15766 | 17427 | 15682 | 16005 | 15636 | 15840 | 16401 | 15896 | 15437 | 16215 | 15946 |
| Solid Fuels | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE |
| Oil and Natural Gas | 10559 | 11010 | 12225 | 13221 | 13768 | 14560 | 15477 | 15766 | 17427 | 15682 | 16005 | 15636 | 15840 | 16401 | 15896 | 15437 | 16215 | 15946 |
| **Industrial Processes** | **31086** | **32121** | **32146** | **32907** | **33795** | **35233** | **35778** | **36670** | **36178** | **37333** | **37371** | **36269** | **36242** | **37279** | **40234** | **40101** | **41645** | **39891** |
| Mineral Products | 8288 | 7324 | 7375 | 7213 | 8070 | 8821 | 8449 | 8996 | 9118 | 9445 | 9627 | 9032 | 9051 | 9083 | 9467 | 9482 | 9609 | 9426 |
| Chemical Industry | 4994 | 4913 | 5118 | 5685 | 5809 | 6525 | 6487 | 6576 | 6560 | 6791 | 6799 | 6116 | 6192 | 6128 | 6837 | 6330 | 6575 | 6240 |
| Metal Production | 9775 | 11464 | 11775 | 12093 | 11310 | 11527 | 11610 | 11480 | 11665 | 11842 | 11795 | 11484 | 11535 | 11624 | 11427 | 11863 | 12849 | 11130 |
| Other Production | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Production of HFCs and $SF_6$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Consumption of HFCs and $SF_6$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Other (please specify) | 8030 | 8419 | 7879 | 7916 | 8606 | 8359 | 9231 | 9619 | 8835 | 9255 | 9151 | 9638 | 9464 | 10444 | 12504 | 12426 | 12613 | 13096 |
| **Solvent and Other Product Use** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** | **NA,NE** |
| **Agriculture** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| Enteric Fermentation | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Manure Management | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Rice Cultivation | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Agricultural Soils | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Prescribed Burning of Savannas | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Other (please specify) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Waste** | **267** | **255** | **261** | **249** | **244** | **238** | **231** | **224** | **216** | **196** | **200** | **200** | **176** | **179** | **182** | **186** | **189** | **193** |
| Solid Waste Disposal on Land | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| Wastewater Handling | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Waste Incineration | 267 | 255 | 261 | 249 | 244 | 238 | 231 | 224 | 216 | 196 | 200 | 200 | 176 | 179 | 182 | 186 | 189 | 193 |
| Other (please specify) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Land Use Change & Forestry** | **-57630** | **-40789** | **-82437** | **-14807** | **-16334** | **164582** | **-56489** | **-87371** | **92123** | **6705** | **-82932** | **-89118** | **64803** | **39897** | **98967** | **31655** | **30748** | **35424** |
| Forest Land | -84135 | -66484 | -104884 | -36114 | -34624 | 147253 | -73222 | -102636 | 76899 | -7253 | -95668 | -100449 | 53907 | 29661 | 89160 | 23044 | 22688 | 28726 |
| Cropland | 12195 | 11696 | 9879 | 8795 | 7235 | 5553 | 5048 | 3933 | 3629 | 2351 | 1657 | 612 | 188 | -755 | -1236 | -2324 | -2603 | -3645 |
| Grassland | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE | NE,NO,IE |
| Wetlands | 4951 | 4835 | 4187 | 3945 | 2621 | 3349 | 3302 | 3277 | 3538 | 3691 | 3141 | 3001 | 2897 | 3230 | 3169 | 2973 | 2830 | 2655 |
| Settlements | 9359 | 9165 | 8380 | 8566 | 8434 | 8427 | 8383 | 8055 | 8058 | 7916 | 7937 | 7718 | 7810 | 7762 | 7875 | 7962 | 7834 | 7687 |
| Other Land | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO |
| **Total, excluding LULUCF** | **455844** | **447282** | **462033** | **460872** | **474990** | **488309** | **501058** | **513259** | **521402** | **536774** | **559878** | **554701** | **561690** | **581759** | **578263** | **569068** | **558318** | **590204** |
| **Total, including LULUCF** | **398214** | **406493** | **379596** | **446064** | **458656** | **652891** | **444570** | **425888** | **613525** | **543479** | **476945** | **465583** | **626493** | **621657** | **677231** | **600723** | **589066** | **625628** |

Table A.1: Emission Trends ($CO_2$) - 1990-2007

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gg | | | | | | | | | | | | | | | | | |
| **Energy** | **1739** | **1792** | **1936** | **2023** | **2118** | **2235** | **2379** | **2439** | **2482** | **2460** | **2567** | **2608** | **2570** | **2595** | **2609** | **2577** | **2596** | **2565** |
| Fuel Combustion Activities | 212 | 201 | 206 | 210 | 216 | 215 | 217 | 210 | 225 | 248 | 250 | 252 | 253 | 251 | 244 | 235 | 236 | 238 |
| Energy Industries | 78 | 73 | 77 | 76 | 80 | 82 | 84 | 78 | 91 | 115 | 119 | 123 | 123 | 123 | 118 | 108 | 108 | 111 |
| Manufacturing and Construction | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Transport | 31 | 30 | 32 | 32 | 33 | 34 | 36 | 35 | 36 | 35 | 33 | 31 | 31 | 30 | 29 | 30 | 29 | 30 |
| Other Sectors | 101 | 95 | 95 | 99 | 100 | 96 | 94 | 95 | 95 | 95 | 95 | 95 | 95 | 94 | 94 | 94 | 97 | 94 |
| Other | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE |
| Fugitive Emissions from Fuels | 1527 | 1592 | 1729 | 1812 | 1902 | 2020 | 2163 | 2229 | 2256 | 2211 | 2317 | 2356 | 2318 | 2345 | 2365 | 2342 | 2359 | 2327 |
| Solid Fuels | 91 | 99 | 87 | 87 | 84 | 82 | 84 | 78 | 65 | 51 | 45 | 47 | 45 | 42 | 31 | 35 | 34 | 36 |
| Oil and Natural Gas | 1436 | 1492 | 1642 | 1725 | 1817 | 1938 | 2078 | 2150 | 2191 | 2160 | 2272 | 2309 | 2272 | 2303 | 2333 | 2307 | 2326 | 2291 |
| **Industrial Processes** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** | **NA,NE, NO,IE** |
| Mineral Products | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chemical Industry | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO |
| Metal Production | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE | NA,NE,IE |
| Other Production | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Production of HFCs and $SF_6$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Consumption of HFCs and $SF_6$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Other (please specify) | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| **Solvent and Other Product Use** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Agriculture** | **923** | **937** | **980** | **990** | **1026** | **1080** | **1104** | **1109** | **1119** | **1130** | **1160** | **1195** | **1210** | **1212** | **1256** | **1280** | **1248** | **1221** |
| Enteric Fermentation | 806 | 820 | 860 | 872 | 905 | 953 | 976 | 980 | 987 | 997 | 1023 | 1054 | 1064 | 1066 | 1108 | 1131 | 1100 | 1078 |
| Manure Management | 116 | 116 | 120 | 118 | 120 | 127 | 128 | 129 | 131 | 133 | 137 | 142 | 146 | 146 | 148 | 149 | 148 | 143 |
| Rice Cultivation | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO |
| Agricultural Soils | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE | NA,NE |
| Prescribed Burning of Savannas | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other (please specify) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Waste** | **855** | **871** | **883** | **897** | **902** | **900** | **897** | **908** | **915** | **926** | **919** | **913** | **925** | **937** | **949** | **962** | **987** | **974** |
| Solid Waste Disposal on Land | 844 | 861 | 872 | 887 | 891 | 889 | 885 | 898 | 905 | 913 | 908 | 902 | 914 | 926 | 937 | 950 | 974 | 962 |
| Wastewater Handling | 11 | 10 | 10 | 10 | 11 | 10 | 12 | 11 | 11 | 13 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 12 |
| Waste Incineration | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other (please specify) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Land Use Change & Forestry** | **178** | **273** | **95** | **340** | **325** | **993** | **240** | **93** | **769** | **333** | **77** | **157** | **583** | **481** | **537** | **287** | **312** | **295** |
| Forest Land | 160 | 254 | 79 | 324 | 311 | 981 | 227 | 80 | 755 | 319 | 64 | 145 | 570 | 468 | 523 | 273 | 299 | 283 |
| Cropland | 14 | 13 | 11 | 10 | 9 | 7 | 8 | 7 | 8 | 7 | 8 | 7 | 8 | 7 | 8 | 7 | 8 | 7 |
| Grassland | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO |
| Wetlands | 0 | 1 | 1 | 0 | NO | 0 | NO | 0 | 1 | 2 | NO | NO | NO | 1 | 1 | 2 | NO | NO |
| Settlements | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Other Land | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| **Total, excluding LULUCF** | **3516** | **3600** | **3799** | **3910** | **4045** | **4215** | **4380** | **4456** | **4516** | **4516** | **4646** | **4717** | **4705** | **4745** | **4814** | **4820** | **4830** | **4760** |
| **Total, including LULUCF** | **3695** | **3873** | **3894** | **4250** | **4370** | **5208** | **4620** | **4549** | **5284** | **4848** | **4723** | **4874** | **5288** | **5226** | **5351** | **5107** | **5142** | **5055** |

Table A.2: Emission Trends ($CH_4$) - 1990-2007

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Gg | | | | | | | | | |
| **Energy** | **27** | **27** | **28** | **30** | **32** | **32** | **33** | **34** | **33** | **34** | **35** | **33** | **33** | **33** | **33** | **33** | **32** | **33** |
| Fuel Combustion Activities | 27 | 27 | 28 | 30 | 32 | 32 | 33 | 34 | 33 | 34 | 35 | 33 | 32 | 33 | 33 | 33 | 32 | 33 |
| Energy Industries | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Manufacturing and Construction | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Transport | 20 | 21 | 21 | 23 | 25 | 25 | 26 | 27 | 26 | 26 | 26 | 25 | 24 | 24 | 24 | 24 | 24 | 25 |
| Other Sectors | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 3 |
| Other | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,NO,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE | NA,IE |
| Fugitive Emissions from Fuels | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Solid Fuels | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO |
| Oil and Natural Gas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Industrial Processes** | **38** | **36** | **36** | **33** | **38** | **38** | **41** | **35** | **20** | **9** | **7** | **7** | **8** | **8** | **14** | **13** | **8** | **8** |
| Mineral Products | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chemical Industry | 38 | 36 | 36 | 33 | 38 | 38 | 41 | 35 | 20 | 9 | 7 | 7 | 8 | 8 | 14 | 13 | 8 | 8 |
| Metal Production | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other Production | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Production of HFCs and $SF_6$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Consumption of HFCs and $SF_6$ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Other (please specify) | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| **Solvent and Other Product Use** | **1** | **1** | **0** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| **Agriculture** | **94** | **92** | **93** | **97** | **101** | **103** | **107** | **107** | **109** | **110** | **110** | **105** | **103** | **110** | **114** | **112** | **112** | **110** |
| Enteric Fermentation | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Manure Management | 11 | 12 | 12 | 12 | 13 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 | 15 |
| Rice Cultivation | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Agricultural Soils | 82 | 80 | 81 | 84 | 88 | 89 | 93 | 93 | 94 | 96 | 96 | 90 | 88 | 95 | 98 | 96 | 96 | 94 |
| Prescribed Burning of Savannas | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other (please specify) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Waste** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **2** |
| Solid Waste Disposal on Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Wastewater Handling | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Waste Incineration | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other (please specify) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Land Use Change & Forestry** | **7** | **11** | **4** | **14** | **14** | **42** | **10** | **4** | **32** | **14** | **3** | **7** | **25** | **20** | **23** | **12** | **13** | **12** |
| Forest Land | 7 | 11 | 3 | 14 | 13 | 41 | 10 | 3 | 32 | 13 | 3 | 6 | 24 | 20 | 22 | 11 | 13 | 12 |
| Cropland | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Grassland | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO |
| Wetlands | 0 | 0 | 0 | 0 | NO | 0 | NO | 0 | 0 | 0 | NO | NO | NO | 0 | 0 | 0 | NO | NO |
| Settlements | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other Land | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| **Total, excluding LULUCF** | **162** | **157** | **159** | **162** | **173** | **176** | **184** | **179** | **164** | **156** | **155** | **148** | **146** | **154** | **163** | **160** | **155** | **155** |
| **Total, including LULUCF** | **169** | **169** | **163** | **177** | **187** | **218** | **194** | **183** | **197** | **170** | **158** | **155** | **171** | **174** | **186** | **172** | **168** | **167** |

Table A.3: Emission Trends ($N_2O$) - 1990-2007

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions of HFCs(3) - (Gg CO2 equivalent) | 767.251 | 835.333 | 655.972 | NA,NO | NA,NO | 479.412 | 851.534 | 1397.69 | 1934.68 | 2453.74 | 2985.39 | 3538.7 | 3917.15 | 4384.76 | 4702.32 | 5223.31 | 5044.19 | 4939.19 |
| HFC-23 | .066 | .071 | .056 | NA,NO | NA,NO | .000056 | .000085 | .0028 | .0004 | .00051 | .00058 | .00064 | .0007 | .00071 | .00074 | .00066 | .00065 | .00067 |
| HFC-32 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | .0000048 | .0000093 | .000042 | .00026 | .00036 | .00061 | .0011 | .0019 | .0034 | .0045 | .0096 | .037 | .06 |
| HFC-41 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO |
| HFC-43-10mee | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | .00089 | .0027 | .0033 | .0029 | .0031 | .0034 | .0025 | .0016 | .0015 | 0014 |
| HFC-125 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | .018 | .029 | .074 | .11 | .15 | .18 | .21 | .24 | .27 | .3 | .35 | .33 | .33 |
| HFC-134 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO |
| HFC-134a | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | .28 | .54 | .74 | .96 | 1.21538 | 1.46605 | 1.72681 | 1.87417 | 1.98593 | 2.09133 | 2.21316 | 2.28247 | 2.21191 |
| HFC-152a | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | .004 | .02 | .043 | .035 | .029 | .043 | .032 | .016 | .015 | .47 | .64 | .3 | .19 |
| HFC-143 | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO |
| HFC-143a | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | .011 | .017 | .051 | .077 | .11 | .14 | .17 | .2 | .24 | .27 | .33 | .28 | .28 |
| HFC-227ea | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | .0058 | IE,NA,NE,NO | IE,NA,NE,NO | .025 | .0077 | .01 | .008 | .0081 | .038 | .0051 | .00066 | .0007 | .00052 |
| HFC-236fa | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | .000063 | .000063 | .000063 | .000063 | .000063 | .00013 | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO |
| HFC-245ca | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO | IE,NA,NE,NO |
| Unspecified mix of listed HFCs(4) - (Gg CO2 equivalent) | NA,NO | NA,NO | NA,NO | NA,NO | NA,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO |
| Emissions of PFCs(3) - (Gg CO2 equivalent) | 6538.83 | 6949.98 | 6556.82 | 6450.32 | 5965.33 | 5489.59 | 5622.83 | 5512.71 | 5601.84 | 4645.28 | 4311.08 | 3500.42 | 2994.81 | 3032.43 | 3058.57 | 3313.31 | 2580.17 | 2188.69 |
| CF4 | .91 | .96 | .91 | .89 | .83 | .76 | .78 | .76 | .77 | .64 | .59 | .48 | .41 | .42 | .42 | .45 | .36 | .3 |
| C2F6 | .071 | .076 | .071 | .07 | .065 | .061 | .063 | .061 | .062 | .052 | .048 | .039 | .033 | .034 | .034 | .039 | .028 | .023 |
| C 3F8 | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | .000000046 | .000044 | .00023 | .00022 | .00019 | .00017 | .00015 | .00014 | .00012 | .00011 | .0001 | .000094 | .000087 |
| C4F10 | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO |
| c-C4F8 | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | .0000000005 | .000000051 | .00000005 | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO |
| C5F12 | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | 00000005 | .0000036 | .000011 | .000011 | .0000015 | .0000015 | .0000015 | .0000015 | .0000015 | .0000015 | .0000015 | .0000015 | .0000015 |
| C6F14 | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | .001 | .0012 | .00031 | .00024 | .0002 | .00022 | .00023 | .00023 | .00023 | .00023 | .00021 | 0002 | .0002 |
| Unspecified mix of listed PFCs(4) - (Gg CO2 equivalent) | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO | NA,NE,NO |
| Emissions of SF6(3) - (Gg CO2 equivalent) | 4703.93 | 5185.41 | 4002.86 | 3810.43 | 3881.92 | 3707.3 | 2803.61 | 3045.8 | 3733. | 3777.22 | 4341.49 | 4372.78 | 4046.08 | 4159.81 | 3034.38 | 2518.49 | 2896.69 | 1782.12 |
| SF6 | .2 | .22 | .17 | .16 | .16 | .16 | .12 | .13 | .16 | .16 | .18 | .18 | .17 | .17 | .13 | .11 | .12 | .075 |

Table A.4: Emission Trends (HFCs, PFCs, $SF_6$) - 1990-2007

## A.2 Policies and Measures Tables

| Status | Definition |
|---|---|
| Implemented | Implemented policies and measures are those for which one or more of the following applies:<br>• national legislation is in force;<br>• one or more voluntary agreements have been established;<br>• financial resources have been allocated;<br>• human resources have been mobilized. |
| Adopted | Adopted policies and measures are those for which an official government decision has been made and there is a clear commitment to proceed with implementation. |
| Planned | Planned policies and measures are options under discussion and having a realistic chance of being adopted and implemented in the future. |

Table A.5: Policies and Measures - Definitions

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| **Energy Efficiency Act** | Energy | Regulatory | Implemented | Federal | Natural Resources Canada | 0.09 | 0.26 | 0.75 | 1.4 | 3.55 |
| *The Government is in the process of amending energy efficiency regulations under the Energy Efficiency Act. Amendments will include the introduction of new performance requirements for currently unregulated products, and tightened requirements for others.* | | | | | | | | | | |
| **Reducing Greenhouse Gas Emissions from New Cars and Light Trucks under the Canadian Environmental Protection Act, 1999 (CEPA, 1999)** | Transport | Regulatory | Planned | Federal | Environment Canada | n/a | n/a | n/a | tbd | tbd |
| *The Government is currently developing regulations that will set mandatory standards to reduce the carbon dioxide tailpipe emissions from new cars and light trucks beginning with the 2011 model year. These standards will be consistent with the national fuel economy standards finalized by the United States on March 27, 2009. Emission reductions have not yet been determined due to the early stage of regulations development.* | | | | | | | | | | |
| **Regulating Renewable Fuels Content** | Transport | Regulatory | Adopted | Federal | Environment Canada | 0. | 0. | 0.3 | 1. | 2.1 |
| *The Government has developed and implemented a federal regulation, under CEPA, 1999, that requires fuel producers and importers to have an average annual renewable fuel content of at least 5% of the volume of gasoline that they produce or import.* | | | | | | | | | | |
| **ecoENERGY Technology Initiative** | Cross-Sectoral | Policy | Implemented | | Natural Resources Canada | n/a | n/a | n/a | n/a | n/a |
| *The ecoENERGY Technology Initiative (ecoETI) is investing $230 million over five years (2007-12) in the research, development and demonstration of clean transformational energy technologies and systems. Given the longer term nature of this project, the investment is expected to lead to reductions in greenhouse gas emissions in the post-2012 period. The Initiative is directed towards increasing clean energy supplies, reducing energy waste and reducing pollution from conventional energy.* | | | | | | | | | | |
| **ecoENERGY for Renewable Power** | Energy | Fiscal | Implemented | Federal | Natural Resources Canada | 2.2 | 3.74 | 5.45 | 6.67 | 6.67 |
| *The ecoENERGY for Renewable Power program is investing $1.48 billion to provide incentives to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, lowimpact hydro, geothermal, solar photovoltaic, and ocean energy. The program will provide an incentive of 1 cent/kWh for up to 10 years to qualifying projects. The program came into effect on April 1, 2007 as projected, and as of March 31, 2009, 52 contribution agreements had been signed with proponents, representing about $900 million in federal funding over 10 years and 2700 MW of renewable power capacity.* | | | | | | | | | |
| **ecoENERGY for Renewable Heat** | Energy | Fiscal | Implemented | Federal | Natural Resources Canada | 0.005 | 0.01 | 0.015 | 0.02 | 0.02 |
| *The ecoENERGY for Renewable Heat initiative is investing approximately $36 million over four years in incentives and industry development to support the adoption of clean renewable thermal technologies such as solar air and solar hot water for water and space heating in buildings. The program achieves GHG reductions by encouraging individuals and organizations to use renewable solar thermal systems.* | | | | | | | | | | |
| **ecoENERGY for Buildings and Houses** | Energy | Fiscal | Implemented | Federal | Natural Resources Canada | 0.32 | 0.56 | 1.13 | 1.157 | 2.02 |
| *The ecoENERGY for Buildings and Houses program is investing $60 million over four years to encourage the construction and operation of more energy-efficient buildings and houses through a range of complementary activities. The Buildings and Houses program has started its third year of operation and is fully implemented.* | | | | | | | | | | |
| **ecoENERGY Retrofit Initiative** | Energy | Fiscal | Implemented | Federal | Natural Resources Canada | 0.46 | 0.67 | 1.2 | 1.66 | 1.66 |
| *The ecoENERGY Retrofit Initiative provides incentives for energy efficiency improvements in homes and in small and medium-sized organizations in the institutional, commercial and industrial sectors. The ecoENERGY Retrofit for Homes provides home and property owners with grants up to $5,000 per unit to offset the cost of making energy efficiency improvements. The Retrofit for Homes program involves residential energy efficiency assessments by certified energy advisors and is complemented by a suite of provincial programs.* | | | | | | | | | | |
| **ecoENERGY for Industry** | Energy | Awareness | Implemented | Federal | Canadian Industry Program for Energy Conservation | 0.17 | 0.27 | 0.37 | 0.4 | 0.4 |
| *The ecoENERGY for Industry program is investing $18 million over four years to encourage information-sharing on new technologies and best practices in energy use, as well as training and specialized assessments for energy managers to identify and implement energy-saving projects. The program is an industry-government partnership delivered through the Canadian Industry Program for Energy Conservation (CIPEC). CIPEC encourages industrial energy efficiency improvements and reductions in GHG emissions through a number of voluntary activities.* | | | | | | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| **ecoAUTO Rebate Program** | Transport | Fiscal | Implemented | Federal | Transport Canada, Service Canada | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| *The ecoAUTO Rebate Program concluded its 2-year mandate on March 31, 2009. It provided a cash incentive to Canadians to help the environment by buying or leasing more fuel-efficient vehicles. Through this initiative, the federal Government offered rebates from $1,000 to $2,000 towards the purchase or lease (12 months or more) of new fuel-efficient vehicles for the model years 2006, 2007 and 2008. Only new eligible vehicles purchased or leased between March 20, 2007 and December 31, 2008, and for which a rebate application form was received by March 31, 2009, qualified for the rebate.* | | | | | | | | | | |
| **The Green Levy** | Transport | Economic | Implemented | Federal | Canada Revenue Agency, Canada Border Services Agency | 0.1 | 0.14 | 0.17 | 0.2 | 0.23 |
| *The Green Levy applies to passenger vehicles with a fuel consumption rating of 13 litres or more per 100 kilometres (55% city and 45% highway) and is imposed at rates ranging from $1,000 to $4,000.* | | | | | | | | | | |
| **ecoENERGY for Personal Vehicles Initiative** | Transport | Awareness | Implemented | Federal | Transport Canada, Service Canada | 0.025 | 0.05 | 0.075 | 0.1 | 0.1 |
| *The ecoENERGY for Personal Vehicles Initiative is investing $21 million over four years to provide Canadians with helpful tips and decision-making tools to assist them with buying, driving and maintaining their vehicles in a manner which reduces fuel consumption and greenhouse gas emissions. Such resources include, but are not limited to: the Fuel Consumption Guide; new driver training; and idle-free and tire inflation campaigns.* | | | | | | | | | | |
| **ecoMobility** | Transport | Economic | Implemented | Federal | Transport Canada, Service Canada | 0. | 0. | 0.109 | 0.11 | 0.112 |
| *The ecoMOBILITY Program aims to reduce emissions from the urban passenger transportation sector by helping municipalities deliver programs, services and policies that attract residents to less polluting forms of transportation. The ecoMobility program is investing $10 million over five years to provide financial support to municipalities and regional transportation authorities for transportation demand management (TDM) projects that demonstrate how municipal initiatives can reduce emissions by shifting personal automobile travel to other modes, reducing the number and length of car trips, and shifting trips to less congested times and routes. The program will help build capacity in municipalities across Canada to implement transportation demand management measures through research, professional development, information sharing and the development of materials / resources.* | | | | | | | | | | |
| **National Vehicle Scrappage Program** | Transport | Fiscal | Implemented | Federal | Clean Air Foundation | 0.005 | 0.023 | 0.032 | 0.024 | 0.001 |
| *The National Vehicle Scrappage Program offers rewards to owners of old high-polluting vehicles to retire them. Program participants may choose one of: a free transit pass, memberships in a car-sharing program, a rebate on the purchase of a newer vehicle (model year 2004 and later) or $300 cash. The primary goal of the program is to reduce smog-forming emissions. Secondary goals are to reduce greenhouse gas emissions by encouraging sustainable transportation alternatives (such as public transit), and by ensuring the responsible recycling of vehicles.* | | | | | | | | | | |
| **ecoTechnology for Vehicles Program** | Transport | Research | Implemented | Federal | Transport Canada, Service Canada | 0. | 0.071 | 0.103 | 0.148 | 0.201 |
| *The ecoTechnology for Vehicles program is investing $15 million over four years to help to accelerate the adoption of advanced vehicle technologies that reduce greenhouse gas (GHG) emissions and promote a reduction of fuel consumption in the Canadian fleet of light-duty vehicles. This objective is achieved by acquiring and testing emerging environmental light-duty vehicle technologies, informing Canadians about these new technologies through showcasing and publications and working in partnership with industry, consumers, other Government departments and key stakeholders.* | | | | | | | | | | |
| **ecoFREIGHT Program** | Transport | | Implemented | Federal | Transport Canada, Service Canada | 0. | 0.975 | 1.118 | 1.246 | 1.372 |
| *The ecoFREIGHT program is aimed at reducing the environmental and health effects of freight transportation through the use of technology. The ecoFREIGHT program is investing $61 million over four years, and includes six initiatives: 1. National Harmonization Initiative for the Trucking Industry: ($6M): Identifying regulatory barriers and solutions in collaboration with provinces and territories, so that the Canadian trucking industry can embrace emissions-reducing technologies. 2. Freight Technology Demonstration Fund: ($10) Establishing cost-shared demonstrations to test and measure new and underused freight transportation technologies in real-world conditions, and disseminating information to industry. 3. Freight Technology Incentives Program: ($10M) Providing cost-shared funding to companies and nonprofit organizations in freight transportation to help them to purchase and install proven emission-reducing technologies. 4. ecoFREIGHT Partnerships: ($7M) Building and maintaining partnerships within the transportation sector to reduce emissions from freight transportation through fast and flexible voluntary actions that can support the regulatory framework. 5. Marine Shore Power Program. ($6M) A five year program demonstrating the use of shore based power for marine vessels in Canadian ports to reduce air pollution from idling ship engines in some of Canada's largest urban centers. 6. ecoEnergy for Fleets. ($22M) Helping commercial fleet and institutional road vehicle operations, cut fuel costs and reduce harmful emissions. The ecoEnergy for fleets initiative will emphasize information sharing, workshops and training to help fleets increase their fuel efficiency.* | | | | | | | | | | |
| **Marine Shore Power Program** | Transport | Economic | Implemented | Federal | Transport Canada, Service Canada | 0. | 0.005 | 0.007 | 0.007 | 0.008 |
| *The Marine Shore Power Program is investing $6 million over four years to demonstrate the use of shore-based power for marine vessels in Canadian ports to reduce air pollution from idling ship engines in some of Canada's largest urban centres.* | | | | | | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| **Public Transit Tax Credit** | Transport | Fiscal | Implemented | Federal | Canada Revenue Agency | 0.032 | 0.033 | 0.035 | 0.036 | 0.038 |
| *The Public Transit Tax Credit allows individuals to claim a non-refundable tax credit for the cost of monthly public transit passes, or passes of a longer duration, and electronic fare cards and weekly passes when used on an ongoing basis. The objectives for the measure are to provide assistance to Canadians by making transit more affordable, to reduce traffic congestion in urban areas, and to improve the environment by lowering greenhouse gas emissions.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund** | Cross-Sectoral | Economic | Implemented | Federal | | 16. | 16. | 16. | 16. | 16. |
| *The federal Government put in place an important instrument for collaboration across jurisdictions on climate change policy. Under the $1.5 Billion Clean Air and Climate Change Trust fund, a trust has been established to support those provinces and territories that identify major projects that will result in real reductions in greenhouse gas emissions and air pollutants. The fund provides provinces and territories with the flexibility to draw down the funds over three years or according to their respective schedule and priorities. The fund is allocated on a per capita basis and provides a minimum of $15 million per province and $5 million per territory to support efforts to develop technology, improve energy efficiency, and undertake other projects that will result in significant environmental benefits.* | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (BC)** | Cross-Sectoral | Economic | Implemented | Federal | British Columbia | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for British Columbia include: extracting energy from sawmill scrap and wood infested with pine beetles; providing clean electricity to remote rural areas now fuelled by dirty diesel, such as electrification of Highway 37; support for the development of a "hydrogen highway" a network of hydrogen fuelling stations for fuel celled buses and vehicles; and support for new geothermal and bio-energy projects, including the capture of bio-gas from landfill sites.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (AB)** | Cross-Sectoral | Economic | Implemented | Federal | Alberta | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Alberta include: identifying the opportunities and addressing the challenges associated with developing a large-scale carbon dioxide capture and storage system in association with the work to be done by the joint Canada-Alberta ecoENERGY Carbon Capture and Storage Task Force; supporting a Clean Coal Front End Engineering Design (FEED) project as the first step towards creating a coal-fired electricity generation facility capable of near-zero emissions; a waste-to-energy project in Edmonton to convert municipal waste into electricity; and a Hydrocarbon Upgrading Demonstration Program, which will invest funding in projects that explore commercial opportunities to upgrade Alberta energy resources into other consumer products, while minimizing environmental impacts.* | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (SK)** | Cross-Sectoral | Economic | Implemented | Federal | Saskatchewan | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Saskatchewan include: continuing development of near-zero CO2 emission electrical generation projects; implementing measures to improve energy efficiency and conservation, including promotion and support for energy reduction by home owners, businesses, farms and communities; development and utilization of renewable and alternative energy sources such as bio-fuels and solar energy technologies; and continuing to lead efforts in carbon capture and sequestration through the International Test Centre for Carbon Dioxide Capture.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (MB)** | Cross-Sectoral | Economic | Implemented | Federal | Manitoba | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Manitoba include: expanding Manitoba's low-income energy efficiency program into additional communities; supporting the creation of new biodiesel plants in rural Manitoba; increasing Manitoba's portfolio of renewable energy to include solar power and bio-gas; and dedicating part of the fund to Manitoba's portion of an east-west Power Grid.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (ON)** | Cross-Sectoral | Economic | Implemented | Federal | Ontario | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Ontario include: clean-energy related projects such as expedited investment in constructing an East-West electrical transmission interconnect with Manitoba; and supporting Ontario's plans to phase out its remaining coal-fired generating stations.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (QC)** | Cross-Sectoral | Economic | Implemented | Federal | quebec | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Quebec include: investments to improve access to new technologies for the trucking sector; a program to develop renewable energy sources in rural regions; a pilot plant for production of cellulosic ethanol; a promotion of geothermal heat pumps in the residential sector; support for technological research and innovation for the reduction and sequestration of greenhouse gases; support for the capture of biogas from landfill sites; and support for waste treatment and energy recovery from agricultural biomass.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (NB)** | Cross-Sectoral | Economic | Implemented | Federal | New Brunswick | n/a | n/a | n/a | n/a | n/a |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for New Brunswick include: developing renewable fuels, such as cellulose ethanol and biodiesel, from agriculture and forest feedstock; assisting in the development of projects that capture methane gases from landfills and use the captured gases to produce energy; examining the use of zero emission technology for clean coal energy generation in Belledune; expanding and enhancing programs to foster the efficient use of energy by residential retrofits for low-income households, innovations for new home construction and energy-efficient lighting alternatives; and promoting the more efficient use of energy by the province's forestry industries and the commercial sector.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (NS)** | Cross-Sectoral | Economic | Implemented | Federal | Nova Scotia | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Nova Scotia include: converting the heating plants at the Capital District Health Authority to burn natural gas; pending the outcome of a strategic environmental assessment, expanding Nova Scotia's portfolio of renewable energy to include funding for one or more tidal power pilot project; establishing the Nova Scotia Municipal Climate and Clean Air Fund to enable Nova Scotia municipalities to take on projects that will reduce carbon emissions; setting aside funds to conduct studies and experiments in the sequestration of Carbon Dioxide; and establishing the Nova Scotia Environmental Technology Fund to support the development, commercialization, and use of new technologies and applications to reduce greenhouse gases.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (PEI)** | Cross-Sectoral | Economic | Implemented | Federal | Prince Edward Island | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Prince Edward Island include: support for homeowners to install renewable energy technologies and make their homes more energy efficient; investment in renewable energy technologies and energy saving measures in government buildings; a program to introduce renewable energy demonstration projects in several Island schools; and a hydrogen fuelling station for the Prince Edward Island Wind-Hydrogen Village.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (NF)** | Cross-Sectoral | Economic | Implemented | Federal | Newfoundland and Labrador | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Newfoundland and Labrador include: measures to improve the energy efficiency of public buildings; greenhouse gas reductions through enhanced waste management techniques, including methane gas recovery and utilization, and expanded composting; and climate change innovations funding to support energy efficiency and the reduction of greenhouse gas production, particularly in rural and remote areas.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (YK)** | Cross-Sectoral | Economic | Implemented | Federal | Yukon | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Yukon include installing a third hydro turbine at the Aishihik hydro electric plant in south-western Yukon to reduce reliance on diesel generated electricity.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (NWT)** | Cross-Sectoral | Economic | Implemented | Federal | Northwest Territories | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for the Northwest Territories include: development of hydro resources including mini-hydro-electric plants to service the small isolated communities of Whati and Lutselk'e; energy conservation activities to reduce household consumption of fossil fuels; an Energy Efficiency Financing Program that supports residents in making energy-saving investments in their homes, appliances and vehicles; establishment of alternative energy projects utilizing wind and heat pumps; and utilization of residual heating systems and surplus hydro capacity to heat public buildings.* | | | | | | | | | | |
| **Clean Air and Climate Change Trust Fund (NV)** | Cross-Sectoral | Economic | Implemented | Federal | Nunavut | n/a | n/a | n/a | n/a | n/a |
| *Under the Clean Air and Climate Change Trust Fund, potential projects for Nunavut include: a program to promote the adoption of energy efficient lighting in public and private housing, businesses and government offices, in tandem with a ban on incandescent light bulbs; a homeowner incentive program that encourages energy efficiency and conservation; and new construction, expansion or rebuilding residual heating systems in eight communities. These systems recover heat from diesel electricity generating plants that is piped to nearby buildings.* | | | | | | | | | | |
| **Improved Climate Change Scenarios** | N/A | Research | Implemented | Federal | Environment Canada | | | | | |
| *Accurate climate information and projections are essential to assess impacts and develop robust adaptation strategies and measures. Improved climate change projections and scenarios will be developed by Environment Canada particularly on extremes and hazards for vulnerable infrastructure (e.g. bridges and sewers, which require extreme rainfall design information) and for communities across Canada.* | | | | | | | | | | |
| **Innovative Risk Management Tools for Adaptation** | N/A | Awareness | Implemented | Federal | Natural Resources Canada | | | | | |
| *Decision-makers can effectively use new knowledge when it is embedded in tools (e.g. guidelines, computer-based analytical models, websites, etc.) for risk assessment and management, economic analysis and adaptation planning. NRCan will produce a basic suite of such tools in collaboration with industry, practitioners, and government partners, to ensure the safety and competitiveness of our communities and economic sectors. This will include related data and information.* | | | | | | | | | | |
| **Regional Adaptation Work Programs** | N/A | Research | Implemented | Federal | Natural Resources Canada | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| | | *Collaboration is required among governments, provinces, communities, businesses and other stakeholders to take effective action. To promote this type of work, NRCan will establish collaborative mechanisms which are customized to reflect regional needs and expertise and will focus on applying information and tools to assess adaptation options and on sharing information.* | | | | | | | | |
| **Assist Northerners in Assessing Key Vulnerabilities and Opportunities** | N/A | Research | Implemented | Federal | Indian & Northern Affairs Canada | | | | | |
| | | *The department will build on current work to advance risk assessment and planning through community-based adaptation projects which assess and identify risks and opportunities related to the impacts of climate change, and increase the capacity of Aboriginal and northern communities to address the impacts of a changing climate.* | | | | | | | | |
| **Climate Change and Health Adaptation in Northern / Inuit Communities** | N/A | Research | Implemented | Federal | Health Canada | | | | | |
| | | *Aboriginal and northern communities and organizations have unique vulnerabilities to climate change in the North including the impacts on health and well-being of sea level rise and violent storms on community location, sanitation, food safety, water quality, and vector-borne diseases and impacts on wildlife and plants used for traditional diet. Health Canada will focus on health in northern communities through culturally sensitive educational and awareness materials and initiatives to enable community action, and on enhancing health promotion at the community level.* | | | | | | | | |
| **Climate and Infectious Disease Alert and Response Systems to Protect the Health of Canadians** | N/A | Research | Implemented | Federal | Health Canada, Public Health Agency of Canada | | | | | |
| | | *Public health, health care and emergency response professionals also require information to take action and to develop adequate strategies. Health Canada and the Public Health Agency will work with partners on alert systems for weather extremes and infectious diseases, guidelines for health professionals, research, surveillance and modeling of infectious diseases, and prevention and control strategies.* | | | | | | | | |
| **Carbon Capture and Storage Funding Act** | Energy | Economic | Implemented | Provincial | Alberta | | | | | |
| | | *Enable Alberta to administer funding to support three to five large-scale carbon capture and storage projects.* | | | | | | | | |
| **Climate Change Emissions Management Amendment Act** | Cross-Sectoral | Regulatory | Implemented | Provincial | Alberta | | | | | |
| | | *Alberta passed this act to regulate GHG emissions from large industry. As of July 1, 2007, companies that emit more than 100,000 tonnes are required to reduce emissions intensity by 12% using an average of 2003 emissions as a baseline.* | | | | | | | | |
| **Climate Change Emissions Management Fund** | Cross-Sectoral | Economic | Implemented | Provincial | Alberta | | | | | |
| | | *This fund invests in projects and technology to reduce emissions. As of December 2008, Alberta companies had paid approximately $122 million into this fund and reduced emissions by 10.2 Mt.* | | | | | | | | |
| **BC Carbon Tax** | Energy | Economic | Implemented | Provincial | British Columbia | | | | | |
| | | *This revenue-neutral tax went into effect on July 1, 2008, and applies to virtually all fossil fuels, including: gasoline, diesel, natural gas, coal, propane, and home heating fuel. The carbon tax started at a rate based on $10 per tonne of associated carbon or carbon-equivalent emissions, and will rise by $5 each year for the next four years - reaching $30 per tonn by 2012. The revenue generated by this tax will be returned to individuals and businesses through reductions of other taxes.* | | | | | | | | |
| **Greenhouse Gas Reductions Targets Act** | Cross-Sectoral | Regulatory | Implemented | Provincial | British Columbia | | | | | |
| | | *The act puts into law BC's target of reducing greenhouse gas emissions by at least 33 per cent below 2007 levels by 2020 and 80 per cent below 2007 levels by 2050. BC was the first province in Canada to legislate its GHG reduction targets. The act also requires that interim targets be set. GHG reduction targets of 6 per cent below 2007 levels by 2012 and 18 per cent below 2007 levels by 2016 were adopted by regulation in December 2008.* | | | | | | | | |
| **Carbon Neutral Government** | Cross-Sectoral | Regulatory | Implemented | Provincial | British Columbia | | | | | |
| | | *The Greenhouse Gas Reductions Targets Act requires the provincial government, including provincial ministries and agencies, schools, colleges, universities, health authorities and Crown corporations, to become carbon neutral by 2010 and to make public a report every year detailing actions taken towards carbon neutrality.* | | | | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| **The Greenhouse Gas Reduction (Cap and Trade) Act** | Cross-Sectoral | Regulatory | Adopted | Provincial | British Columbia | | | | | |
| *This legislation enables the implementation of a cap and trade system in BC in conjunction with regional partners. Under the act, the BC government will establish the cap for designated large emitters by issuing a limited number of tradable compliance units (emissions allowances) for given periods of time (compliance periods). Each designated emitter will then be required to obtain a number of compliance units equivalent to the amount of regulated greenhouse gas emissions it releases within the specified compliance period. The act also authorizes the creation of a compliance unit tracking system for the banking, transfer and surrender of compliance units. The legislation will also provide for the use of administrative penalties that will be set by regulation, and which will apply as an automatic consequence of non-compliance.* | | | | | | | | | | |
| **The Greenhouse Gas Reduction (Emissions Standards) Statutes Amendment Act** | Cross-Sectoral | Regulatory | Implemented | Provincial | British Columbia | | | | | |
| *Requires owners or operators of waste management facilities – including landfills, composting facilities and sewage treatment plants – to reduce, capture or use waste-generated greenhouse gases. Legislates the 2007 Energy Plan commitment to require any coal-fired electricity generation facilities to capture and sequester the greenhouse gas emissions from the combustion of coal. Legislates the 2007 Energy Plan commitment to require that electricity generation facilities that use other fossil fuels have "net zero" emissions, which means that they must use offsets to balance their GHG emissions. Effective January 1, 2009, the Landfill Gas Management Regulation established province-wide criteria for landfill gas capture from municipal solid waste landfills.* | | | | | | | | | | |
| **Local Government (Green Communities) Statutes Amendments Act and Carbon-Neutral Communities** | Cross-Sectoral | Regulatory | Adopted | Provincial | British Columbia | | | | | |
| *The Act amends existing legislation to: require local governments to set greenhouse gas emission targets, policies and actions in Official Community Plans and Regional Growth Strategies; allow local governments to reduce off-street parking requirements where developers are including green elements, and fund alternative transportation infrastructure from payments made in-lieu of off-street parking; provide local governments with broader authority to waive or reduce development cost charges for low environmental impact developments. Over 90 per cent of the province's local governments have committed to be carbon neutral by 2012.* | | | | | | | | | | |
| **Renewable and Low carbon Fuel Requirements Act** | Transport | Regulatory | Implemented | Provincial | British Columbia | | | | | |
| *The act creates a regulatory framework that enables the Province to set benchmarks for the amount of renewable fuel in BC's transportation fuel blends, reduce the carbon intensity of transportation fuels and meet its commitment to adopt a low-carbon fuel standard similar to California's. BC is targeting at least a 10 per cent reduction in the average carbon intensity of transportation fuels by 2020. Industry will determine how best to meet the standard. Regulation came into force January 1, 2009 requiring 5% renewable content in gasoline and diesel, beginning in 2010. Biofuel sales in 2009 can be used for compliance with 2010 requirement.* | | | | | | | | | | |
| **Motor Vehicle and Tailpipe Emissions Standards** | Transport | Standards | Adopted | Provincial | British Columbia | | | | | |
| *The act enables the adoption of vehicle emissions standards equivalent to those laid out in California's regulation that will increase automobile fuel efficiency. 2011 will be the first model year that will be regulated. The act also provides BC with authority to require larger vehicle manufacturers to include a percentage (or set number) of zero emission vehicles in their fleets per year. Under the act, automakers' fleets of passenger cars and light-duty trucks will not be allowed to exceed pre-determined fleet-average GHG emission standards. The "fleet-average" approach will allow manufacturers to keep selling vehicles that exceed the allowed emissions – provided they sell enough low-emission vehicles for their fleets to meet the new average standards.* | | | | | | | | | | |
| **BC's Energy Plan** | Energy | Policy | Implemented | Provincial | British Columbia | | | | | |
| *This 2007 plan includes measures to reduce emissions from the energy sector, such as: requirements for net zero GHG emissions from new electrical power generation (including coal-fired) and from existing thermal power generation by 2016; a target to acquire 50% of incremental resource needs through conservation by 2020; and a $25 million Innovative Clean Energy Fund to encourage commercialization of alternative energy solutions. The province is working with industry to install 100,000 solar roofs on residential and commercial buildings by 2020.* | | | | | | | | | | |
| **2008 Utilities Commission Amendment Act** | Energy | Regulatory | Adopted | Provincial | British Columbia | | | | | |
| *The act legislates a variety of clean energy commitments, including: achieving electricity self-sufficiency in BC by 2016 (special direction in BCUC in place); for 90 per cent of BC's electricity to continue to come from clean and renewable sources; installing smart meters in all BC homes by the end of 2012 (regulation expected soon); continuing BC Hydro's standing offer for clean electricity projects of 10 megawatts or less; implementing a new process for the BCUC to ensure that the Province's electricity transmission system remains consistent with North American reliability standards (regulation in place); new policies that encourage the use of demand side management by public utilities; and every six years, conducting a Long Term Transmission Planning Inquiry to maximize efficiency of BC's transmission lines while providing necessary infrastructure to promote renewable electricity across BC.* | | | | | | | | | | |
| **Carbon Capture and Sequestration** | Energy | Research | Planned | Provincial | British Columbia | | | | | |
| *New investments will be made in carbon sequestration technology.* | | | | | | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| **Pacific Carbon Trust** | Cross-Sectoral | Economic | Implemented | Provincial | British Columbia | | | | | |
| *This provincial Crown corporation was set up by the BC government to acquire credible greenhouse gas offsets on its behalf and meet government's target of of a carbon-neutral public sector by 2010.* | | | | | | | | | | |
| **Community Action on Energy and Emissions Program** | Energy | Economic | Implemented | Provincial | British Columbia | | | | | |
| *Fifty-two BC communities have received a total of $1.6 million under this program to assist in developing efficiency projects that meet specific local needs.* | | | | | | | | | | |
| **Bioenergy Network** | Energy | Economic | Implemented | Provincial | British Columbia | | | | | |
| *Budget 2008 includes $25 million for a Bioenergy Network, which is a key part of the strategy. It will encourage research and development in areas such as woodwaste cogeneration, biofuel production and wood pellet production. The network will also be responsible for directing research and initiating projects that promote the development and use of fuel from organic resources. BC has an abundance of bioenergy opportunities, such as using biomass from the pine beetle outbreak to stimulate investment and economic diversification while generating clean energy. The Province will develop at least 10 community energy projects that convert local biomass into energy by 2020.* | | | | | | | | | | |
| **The Pacific Institute for Climate Solutions** | Cross-Sectoral | Research | Implemented | Provincial | British Columbia | | | | | |
| *British Columbia invested $94.5 million to assist BC's research intensive universities undertake research and generate solutions to key climate action questions and challenges.* | | | | | | | | | | |
| **Future Forest Ecosystems Initiative** | Forestry | Policy | Implemented | Provincial | British Columbia | | | | | |
| *The Future Forest Ecosystems Initiative will help adapt forest and range management to a changing climate.* | | | | | | | | | | |
| **Zero Net Deforestation** | Forestry | Policy | Planned | Provincial | British Columbia | | | | | |
| *To protect British Columbia's forests as a critical resource and carbon sink, BC is legally mandating that any forest loss associated with development or other land use change will be offset by an equivalent number of new trees being planted elsewhere. This ensures no net reduction in forest lands covering an area larger than France. The full value of forest carbon storage is realized while maintaining the responsibility to manage the forests for future generations while reducing greenhouse gasses. The Province will enact the legislation in 2010, with 2015 as the goal for implementation.* | | | | | | | | | | |
| **"Wood First" Policy** | Forestry | Policy | Adopted | Provincial | British Columbia | | | | | |
| *World-leading commitment to increase demand for wood products by requiring that all provincially-funded building projects use wood as the primary construction material where possible. This supports reducing emissions through carbon-friendly building materials and the development of expertise in wood engineering and design and job stability for forest workers. This legislated commitment will be augmented by an international marketing program to China and other Asian countries to adopt wood and wood building technologies that are cheaper, more durable and better for the environment than concrete or other traditional technologies and materials.* | | | | | | | | | | |
| **Forests For Tomorrow** | Forestry | Policy | Implemented | Provincial | British Columbia | | | | | |
| *Forests for Tomorrow is about reforesting areas hardest hit by the mountain pine beetle and past wildfires. The program works to ensure resilient forest ecosystems and sustainable forests by planting the right tree species in the right areas to ensure faster growth and healthy forests. Over six billion trees have been planted in BC since replanting efforts began in the 1930s.* | | | | | | | | | | |
| **Accelerating forest growth** | Forestry | Policy | Implemented | Provincial | British Columbia | | | | | |
| *$21 million to increase growth in BC's forests and reduce losses due to forest health problems. This initiative recognizes the key role our forests play in advancing climate action - 15,000 ha of forest land fertilized sequestering 300,000 tonnes CO2.* | | | | | | | | | | |
| **Towns for Tomorrow** | Cross-Sectoral | Economic | Implemented | Provincial | British Columbia | | | | | |
| *Towns for Tomorrow is investing $21 million over three years for capital projects that will help achieve the Province's vision of vibrant, integrated, creative and prosperous communities. Projects will be cost shared 80/20 (provincial/ municipal) with a maximum provincial contribution of $400,000. Eligible applicants are incorporated municipalities with populations of 5,000 persons or less and the Central Coast Regional District.* | | | | | | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| **Living Water Smart Plan** | Cross-Sectoral | Awareness | Implemented | Provincial | British Columbia | | | | | |
| *British Columbia's Water Plan includes measures to help communities prepare for drought and flooding.* | | | | | | | | | | |
| **LEED Standards** | Cross-Sectoral | Policy | Implemented | Provincial | British Columbia | | | | | |
| *In 2007 the province committed that all new provincially-owned or leased facilities must be built to LEED (Leadership in Energy and Environmental Design) Gold Standards.* | | | | | | | | | | |
| **Green Building Code** | Cross-Sectoral | Policy | Implemented | Provincial | British Columbia | | | | | |
| *Housing: New insulation standards will improve energy efficiency for houses and multifamily residential buildings under five stories. New insulation standards have also been developed for small commercial and industrial buildings. Commercial Buildings: Larger buildings must meet the ASHRAE 90.1(2004).* | | | | | | | | | | |
| **Adaptation Strategy** | Cross-Sectoral | Policy | Implemented | Provincial | British Columbia | | | | | |
| *BC's Climate Action Plan includes adaptation, and highlights the provincial commitment to climate change research, protecting forests and water, and helping communities adapt. The province has established an interagency adaptation committee to provide strategic advice regarding adaptation. Several ministries have established sector-specific adaptation initiatives. The province is leading work to help coastal communities prepare for sea level rise. In late 2009 BC approved a new, more comprehensive Adaptation Strategy which will be implemented over the years to come.* | | | | | | | | | | |
| **Climate Action Industry Working Groups** | Industry | Outreach | Implemented | Provincial | British Columbia | | | | | |
| *Symposiums have been held across the province involving the participation of the forest industry, mining, oil and gas producers, waste and landfill management, agriculture, labour, and transportation. The sessions are solution oriented as government and key economic groups come together to explore options and determine next steps.* | | | | | | | | | | |
| **Green Transit Expansion** | Transport | Economic | Implemented | Provincial | British Columbia | | | | | |
| *$14-billion transit plan to significantly expand transit throughout the province.* | | | | | | | | | | |
| **Electrifying Ports** | Transport | Economic | Implemented | Provincial | British Columbia | | | | | |
| *Recently completed Canada's first electric shore power project at Port Metro Vancouver to reduce marine diesel engine emissions from cruise ships.* | | | | | | | | | | |
| **Gateway Program** | Transport | Economic | Implemented | Provincial | British Columbia | | | | | |
| *The Gateway Program was established by the Province of BC in response to the impact of growing regional congestion, and to improve the movement of people, goods and transit throughout Greater Vancouver. Gateway roads and bridge improvements are proposed to complement other regional road and transit improvements already planned or underway* | | | | | | | | | | |
| **Support for hydrogen and fuel cell technology development** | Transport | Research | Implemented | Provincial | British Columbia | | | | | |
| *The Hydrogen Highway, from BC to Baja California, announced in 2005, is a large-scale, co-ordinated demonstration and deployment program for hydrogen and fuel cell technologies. The program is a partnership among industry, government, academic institutions and others in BC, California and hopefully, other Pacific coast states. The initiative will include a fleet of 20 new BC Transit fuel-cell buses based in Whistler for the Olympics. This will be the world's largest fuel cell fleet operating in a single location.* | | | | | | | | | | |
| **Clean buses, trucks** | Transport | Economic | Implemented | Provincial | British Columbia | | | | | |
| *In 2007, the Province announced $50 million for the purchase of new, cleaner transit buses province wide. A further $10.6 million has been provided to school districts to invest in clean-energy school buses. British Columbia has also invested $500,000 in Green Fleets BC, a partnership initiative led by the Fraser Basin Council to help reduce emissions from vehicle fleets of all kinds.* | | | | | | | | | | |
| **LiveSmart BC: Efficiency Incentive Program** | Energy | Economic | Implemented | Provincial | British Columbia | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| | *The first phase of LiveSmart BC is a three-year, $60-million Efficiency Incentive Program that gives homeowners access to rebates for audits and energy efficiency retrofits.* | | | | | | | | | |
| **PST exemption for hybrid and fuel-efficient vehicles** | Transport | Economic | Implemented | Provincial | British Columbia | | | | | |
| | *British Columbia has waived the Provincial Sales Tax on hybrid vehicles since 2002, saving buyers up to $2,000. A similar sales tax exemption is now also in place for alternative-fuel vehicles, saving buyers up to $2,000. All vehicles that qualify for the federal government's Eco-Auto Rebate will also be GST exempt until the end of 2008. With the two programs combined, BCns could save up to $4,000 on the purchase of a fuel-efficient vehicle. The PST exemption has also been extended to include other environmentally friendly forms of transportation, including electric-assisted bicycles, scooters and electric motorcycles.* | | | | | | | | | |
| **Anti-idling** | Transport | Policy | Implemented | Provincial | British Columbia | | | | | |
| | *Wherever possible, British Columbia will encourage campaigns and regulations designed to reduce this practice as much as possible. Anti-idling regulations will be introduced for the public sector fleet for 2009. Similar measures will be extended province wide by 2010. Finally, support will be provided to ensure that all communities have anti-idling policies in place by 2012.* | | | | | | | | | |
| **Green Lights Transportation Program** | Transport | Policy | Implemented | Provincial | British Columbia | | | | | |
| | *$3 million will support a new Green Lights Transportation Program. It will use technology to assess commercial vehicles for compliance with trucking regulations while they're moving – so they don't have to pull over and idle while they wait for inspections.* | | | | | | | | | |
| **Stopping waste at the source** | Waste Management | Policy | Planned | Provincial | British Columbia | | | | | |
| | *The BC government is exploring options that will help make manufacturers more responsible for the packaging and other waste created by their products. BC will encourage alternative, environmentally friendly forms of packaging and help create an environment that recognizes the need to reduce waste wherever possible.* | | | | | | | | | |
| **Keeping organic waste out of landfills** | Waste Management | Policy | Planned | Provincial | British Columbia | | | | | |
| | *Regional districts are responsible for solid waste management in British Columbia, and nine out of 27 have policies in place to keep organic material out, diverting it instead to home and community composting. The Province has supported these efforts and the expansion of such initiatives.* | | | | | | | | | |
| **International Carbon Action Partnership** | Cross-Sectoral | Policy | Implemented | Provincial | Quebec | | | | | |
| | *During the Poznan conference in December 2008, Quebec announced that it had joined the International Carbon Action Partnership, a coalition of North American and European governments that supports the global carbon marketplace as a tool in the fight against climate change.* | | | | | | | | | |
| **Saskatchewan The Management and Reduction of Greenhouse and Adaptation to ClimateChange Act** | Cross-Sectoral | Economic | Adopted | Provincial | Saskatchewan | | | | | |
| | *The Act provides for new climate change institutions including an Office of Climate Change, regulation of major greenhouse gas emitters, Technology Fund, Climate Change Foundation and Performance Agreements. Authorities are created to set GHG reduction targets and carbon compliance prices.* | | | | | | | | | |
| **Saskatchewan GHG reduction targets** | Cross-Sectoral | Economic | Adopted | Provincial | Saskatchewan | | | | | |
| | *In 2009, Saskatchewan committed to reduce its GHG emissions by 2020 by 20% from 2006 levels* | | | | | | | | | |
| **Go Green Fund** | Cross-Sectoral | Economic | Implemented | Provincial | Saskatchewan | | | | | |
| | *Program offers rebates on insurance and registration for hybrid and fuel efficient vehicles, homeowner loans for renewable fuels, rebates for self generated green electricity and net metering. The program encourages research and demonstration in low carbon technologies2* | | | | | | | | | |
| **Green PST exemption** | Cross-Sectoral | Fiscal | Implemented | Provincial | Saskatchewan | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| *Removal of provincial sales tax on Energy Star appliances* | | | | | | | | | | |
| **SaskPower Eneraction** | Cross-Sectoral | Economic | Implemented | Provincial | Saskatchewan | | | | | |
| *Provides for planning, implementation and monitoring acrtivities to reduce customer power consumption with building retrofits, energy audits, financial incentives for commercial and municipal lighting, transmission and generating systems, efficiency improvements and promotion of Energy Star appliances.* | | | | | | | | | | |
| **Electrical Generating Strategy** | Energy | Economic | Planned | Provincial | Saskatchewan | | | | | |
| *Throne Speech commitment to a new provincial energy generating strategy with a significant commitment to wind power.* | | | | | | | | | | |
| **Green Options Plan and Green Options Partners Program** | Energy | Economic | Adopted | Provincial | Saskatchewan | | | | | |
| *Targets an increase of 200 megawatts to SaskPower's generating capacity with a reduction of CO2 emissions of 225,000 tonnes per year* | | | | | | | | | | |
| **International Performance Assessment Centre for geologic storage for CO2** | Cross-Sectoral | Research | Implemented | Provincial | Saskatchewan | | | | | |
| *Partnership between the University of Regina, Government of Saskatchewan and Shell Canada to create a global network of advice and experience on CCS best practices and regulatory requirements.* | | | | | | | | | | |
| **SaskPower demonstration CCS project** | Energy | Economic | Adopted | Provincial | Saskatchewan | | | | | |
| *1.4 billion dollar government/industry partnership to rebuild a coal fired thermal power gebnerating unit at Boundary Dam. $240 million in federal funding. Captures 1Mt tonnes of CO2 per year and will reduce emissions by 7.2% from 2002 levels.* | | | | | | | | | | |
| **Saskatchewan-Montana CCS storage** | Energy | Economic | Planned | Provincial | Saskatchewan | | | | | |
| *Cross border CCs cooperation and research project involving CCs capture from Saskatchewan and transportation to, and geologic storage in Montana. Includes training for CCs at Regina and Montana State Universities.* | | | | | | | | | | |
| **Biofuel distribution** | Transport | Economic | Implemented | Provincial | Saskatchewan | | | | | |
| *Requires all Saskatchewan distributors to distribute an average blend of 7.5% ethanol in unleaded gasolene. Province works with industry to develop E-85 blends of 85% ethanol and 15% gasolene in selected corridiors* | | | | | | | | | | |
| **MOU Saskatchewan & Victoria** | Cross-Sectoral | Research | Adopted | Provincial | Saskatchewan | | | | | |
| *MOU with State of Victoria, Australia creating a partnership for research and development of low carbon technologies, redewable energy sources and climate change adaptation initiatives.* | | | | | | | | | | |
| **Yukon Government's Climate Change Action Plan** | Cross-Sectoral | Policy | Adopted | Provincial | Yukon | | | | | |
| *Released in 2009, this action plan identifies priority areas for action on climate change including knowledge and understanding of climate change, adapting to climate change, reducing greenhouse gas emissions and leading Yukon action in response to climate change.* | | | | | | | | | | |
| **Carbon Capture and Storage Funding Act** | Energy | Economic | Implemented | Provincial | Alberta | | | | | 1. |
| *Enable Alberta to administer funding to support three to five large-scale carbon capture and storage projects.* | | | | | | | | | | |
| **Climate Change Emissions Management Amendment Act** | Cross-Sectoral | Regulatory | Implemented | Provincial | Alberta | 11. | 11. | 12. | 12. | 12. |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| *Alberta passed this act to regulate GHG emissions from large industry. As of July 1, 2007, companies that emit more than 100,000 tonnes are required to reduce emissions intensity by 12% using an average of 2003 emissions as a baseline.* | | | | | | | | | | |
| **Climate Change Emissions Management Fund** | Cross-Sectoral | Economic | Implemented | Provincial | Alberta | | | | 1.5 | 1.5 |
| *This fund invests in projects and technology to reduce emissions. As of December 2008, Alberta companies had paid approximately $122 million into this fund and reduced emissions by 10.2 Mt.* | | | | | | | | | | |
| **Renewables Fuels Standard** | Transport | Regulatory | Planned | Provincial | Alberta | | | 1. | 1. | 1. |
| *The RFS was announced with the Provincial Energy Strategy (PES) in December 2008. The RFS will mandate blending of renewable fuel: 2 per cent renewable diesel and 5 per cent renewable alcohol (e.g., ethanol) starting July 1, 2010.* | | | | | | | | | | |
| **Energy Efficiency Requirements** | Cross-Sectoral | Fiscal | Planned | Provincial | Alberta | | | | | |
| *Incentives, buildings codes, etc. under development.* | | | | | | | | | | |
| **Consumer Incentive Program** | Energy | Economic | Implemented | Provincial | Alberta | | | | | |
| *A three year $36 million consumer incentive program went into effect in April 2009. The incentives apply to energy audits, furnace/boiler replacement, domestic hot water systems, clothes washers, installation of insulation and new energy efficient homes. The program has already distributed almost $6 million and the program could save up to 1Mt over the life of the equipment.* | | | | | | | | | | |
| **Alberta Building Code** | Cross-Sectoral | Regulatory | Planned | Provincial | Alberta | | | | | |
| *Alberta has committed to developing energy efficiency standards for incorporation in the Alberta Building Code. Impact studies of potential changes to the code have been completed along with consultation. Code changes that will apply to both houses and other buildings are slated to be developed and adopted by the end of 2010.* | | | | | | | | | | |
| **Municipal Climate Change Action Plan** | Cross-Sectoral | Awareness | Implemented | Provincial | Alberta | | | | | |
| *A Municipal Climate Change Action Plan has been developed to build capacity in municipalities in Alberta. The Action Plan is an agreement between the Alberta Urban Municipalities Association, the Alberta Municipal Districts and Counties Association and the Alberta Government. Resources will be put in place to help municipalities take local action on climate change.* | | | | | | | | | | |
| **Western Climate Initiative** | Cross-Sectoral | Economic | Implemented | Provincial | Ontario, Quebec, British Columbia, Manitoba | | | | | |
| *Members include the Provinces of Ontario, Quebec, British Columbia, and Manitoba, and the States of Arizona, California, New Mexico, Oregon, Utah, Montana, and'Washington. Members have set a regional GHG emissions reduction target of 15% below 2005 levels by 2020. A cap and trade system will also be developed for industry.* | | | | | | | | | | |
| **Renewable Portfolio Standard** | Energy | Standards | Implemented | Provincial | New Brunswick | | | | | |
| *This Standard requires that an additional 10% of New Brunswick's electricity must come from renewable sources by 2016. Currently, 23% of the province's electricity comes from renewable sources.* | | | | | | | | | | |
| **Beyond Kyoto** | Cross-Sectoral | Policy | Implemented | Provincial | Manitoba | | | | | |
| *Manitoba released "Beyond Kyoto" in April 2008, a plan to reach its proposed legislated Kyoto target of 6% below 1990 levels by 2012, detailing 60 specific actions and more than $145 million in investments over four years. The plan covers all sectors and focuses on expanding renewable energy, improving energy efficiency, and reducing emissions from transport and agricultural sectors.* | | | | | | | | | | |
| **Climate Change and Emissions Reductions Act** | Cross-Sectoral | Regulatory | Implemented | Provincial | Manitoba | | | | | |
| *This provincial act received royal assent in June 2008. Its initial target is to reduce emissions by 2012, to an amount that is at least 6% less than Manitoba's total 1990 emissions. Manitoba aims to achieve this goal through various initiatives.* | | | | | | | | | | |
| **Vehicle Standards Advisory Board** | Transport | Standards | Implemented | Provincial | Manitoba | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| *Part of the Climate Change and Emissions Reductions Act, this board was established to help determine an efficiency or emissions standard to take effect by 2010, in conjunction with the California standard* | | | | | | | | | | |
| **Clean Energy Transfer Initiative** | Energy | Economic | Implemented | Provincial | Manitoba | | | | | |
| *Part of the Climate Change and Emissions Reductions Act, this commitment of $3 billion over 10 years promotes enhancements to the east-west power grid to sell hydro power to other jurisdictions.* | | | | | | | | | | |
| **Coal-reduction Strategy** | Energy | Economic | Implemented | Provincial | Manitoba | | | | | |
| *Part of the Climate Change and Emissions Reductions Act, this includes a tax on coal emissions; capital support for coal-reliant industries to convert to cleaner energy; and support for developing biomass, which is a coal alternative.* | | | | | | | | | | |
| **Sustainable Agriculture Practices Program** | Agriculture | Standards | Implemented | Provincial | Manitoba | | | | | |
| *Part of the Climate Change and Emissions Reductions Act, this is aimed at best practices to reduce on-farm GHG emissions including cropping and livestock strategies and wetland restoration incentives.* | | | | | | | | | | |
| **Midwestern Regional Greenhouse Gas Reduction Accord** | Cross-Sectoral | Economic | Implemented | Provincial | Manitoba | | | | | |
| *This accord, signed by Manitoba in 2007, was to complete development of a proposed cap and trade system, and to set targets for greenhouse gas emission reductions consistent with the 60-80% recommended by the IPCC.* | | | | | | | | | | |
| **New Brunswick Climate Change Action Plan** | Cross-Sectoral | Policy | Implemented | Provincial | New Brunswick | | | | | |
| *This plan, released in 2007, intends to reduce New Brunswick's GHG emissions to 1990 levels by 2012, with plans to achieve further reductions of 10% below 1990 levels by 2020.* | | | | | | | | | | |
| **New England Governors/Eastern Canadian Premiers Climate Change Action Plan** | Cross-Sectoral | Policy | Implemented | Provincial | New Brunswick, Newfoundland, Nova Scotia, New Brunswick | | | | | |
| *This plan includes a commitment to reduce regional GHG emissions to 1990 levels by 2010, 10% below 1990 levels by 2020, and recognizes a long-term need to require reductions of 75-80%.* | | | | | | | | | | |
| **Northwest Territories Energy Plan** | Energy | Policy | Implemented | Provincial | Northwest Territories | | | | | |
| *Released in 2007, this plan is to guide decisions on energy use and development. Its goals include reducing reliance on imported fuel, reducing energy costs an GHG emissions and maximizing the benefits to northerners of energy development.* | | | | | | | | | | |
| **Environmental Goals and Sustainable Prosperity Act** | Cross-Sectoral | Regulatory | Implemented | Provincial | Nova Scotia | | | | | |
| *Passed in 2007, this includes a commitment to reduce GHG emissions to 10% below 1990 levels by 2020. The plan also includes a short-term target of being halfway there by 2015, and a long-term target of up to 80% reduction by 2050.* | | | | | | | | | | |
| **Climate Change Action Plan** | Cross-Sectoral | Policy | Adopted | Provincial | Ontario | | | | | |
| *Released in August 2007, this is a framework for action to help Ontario reduce its total emissions and adapt to the impacts of climate change. The CCAP sets out provincial targets of 6% reduction in GHG emissions from 1990 levels by 2014, 15% by 2020 and 80% by 2050.* | | | | | | | | | | |
| **Cap and Trade** | Cross-Sectoral | Economic | | Provincial | Ontario | | | | | |
| *Ontario is working with other jurisdictions to support the development of regional based cap and trade systems including: an MOU with Quebec, the Western Climate Initiative, the Midwestern GHG Reduction Accord, the Regional GHG Initiative and the International Carbon Action Partnership.* | | | | | | | | | | |
| **Afforestation** | Forestry | Policy | Adopted | Provincial | Ontario | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| *Includes two afforestation programs in southern Ontario: 1) A program with Trees Ontario to plant 50 million trees in southern Ontario by 2020 and 2) A program with Evergreen Foundation to plant 100,000 trees in cities and urban areas by 2010* | | | | | | | | | | |
| **Biogas Financial Assistance Program** | Agriculture | Policy | Adopted | Provincial | Ontario | | | | | |
| *A three-year $11.2-million investment, launched in September 2007, to help farmers and agri-food businesses develop biogas projects and the further expansion of existing projects in Ontario that produce clean energy, reduce electricity costs and contribute to local economies.* | | | | | | | | | | |
| **2006 Building Code Changes** | Energy | Regulatory | Adopted | Provincial | Ontario | | | | | |
| *Legislation which mandates increased energy efficiency for new buildings and for buildings undergoing renovation. Code changes are being phased in between 2006 and 2011 to give industry time to prepare. Emission reductions associated with this initiative come from natural gas and other fossil fuel demand reductions – electricity conservation impacts are reflected under Coal Phase-Out and related energy policies.* | | | | | | | | | | |
| **Coal Phase-Out and Related Energy Policies** | Energy | Policy | Adopted | Provincial | Ontario | | | | | |
| *Phasing out the province's use of coal-fired electricity by December 2014. There are numerous initiatives that are critical for the completion of Coal Phase-Out, including Clean Energy Supply, Renewable Energy Supply, and Conservation Programs.* | | | | | | | | | | |
| **Conversion to Electric Buses** | Transport | Policy | Adopted | Provincial | Ontario | | | | | |
| *A $180.1-million funding program to support the replacement of ageing municipal transit buses and provide long-term, sustainable funding.* | | | | | | | | | | |
| **Green Energy Act and Other Existing Efficiency Policies** | Energy | Regulatory | Adopted | Provincial | Ontario | | | | | |
| *An act that sets minimum energy-efficiency standards for specified energy-using products and provides descriptions of the responsibilities of dealers with respect to these products.* | | | | | | | | | | |
| **Green Commercial Vehicle Program/Anti-Idling Retrofits** | Transport | Policy | Adopted | Provincial | Ontario | | | | | |
| *A four-year $15-million program that provides funding in the form of grants for companies to 1) Purchase hybrid and alternative-fuel vehicles; and 2) Retrofit heavy-duty vehicles with anti-idling technologies.* | | | | | | | | | | |
| **Heavy Truck Speed Limiters** | Transport | Regulatory | Adopted | Provincial | Ontario | | | | | |
| *A $425K program to develop mandatory speed limiters for all large trucks operating in the province. A speed limiter is an electronic device within a truck engine that caps the truck's top speed at a maximum of 105 km/h. Mandatory speed limiter requirements are now in place.* | | | | | | | | | | |
| **Home Energy Savings Program** | Energy | Policy | Adopted | Provincial | Ontario | | | | | |
| *A $372-million grant program to assist homeowners with completing an energy audit and associated retrofit work. The program also educates the public about where and how to improve energy efficiency in homes and reduce emissions.* | | | | | | | | | | |
| **Methane Landfill Capture** | Waste Management | Regulatory | Adopted | Provincial | Ontario | | | | | |
| *Involves regulations which require landfill methane gas collection for new, expanding or operating landfills larger than 1.5 million cubic metres total waste disposal volume.* | | | | | | | | | | |
| **Ontario Bus Replacement Program & Public Transit Commitments** | Transport | Policy | Adopted | Provincial | Ontario | | | | | |
| *The province is supporting the achievement of GHG reductions through numerous funding programs and projects for transit. Dedicated transit programs such as Gas Tax Funding and the Ontario Bus Replacement Program provide municipalities with transit funding to renew, improve and expand their systems. Significant provincial investment in GO Transit will also help deliver top quality inter-regional transit service, serving millions of riders every year.* | | | | | | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| **Places to Grow Act** | Cross-Sectoral | Regulatory | Adopted | Provincial | Ontario | | | | | |
| *An act that provides legal authority for the 2006 Growth Plan for the Greater Golden Horseshoe, a 25-year vision and plan to manage growth and development in ways that support economic prosperity, protect the environment and help communities achieve a high quality of life.* | | | | | | | | | | |
| **The Big Move** | Transport | Policy | Adopted | Provincial | Ontario | | | | | |
| *A 25-year Regional Transportation Plan to improve regional transportation, bolster global competitiveness, protect the environment and enhance quality of life. The RTP has a number of objectives which include providing transportation choices, promoting active and healthy lifestyles, and increasing interconnectedness in the GTHA.* | | | | | | | | | | |
| **Atlantic Energy Framework for Collaboration** | Energy | Policy | Implemented | Provincial | New Brunswick, Newfoundland & Labrador, Nova Scotia, Prince Edward Island | | | | | |
| *This is an agreement designed to increase cooperation on the energy development to proudce a more sustainable, reliable, and secure energy supply. This cooperation will be required if the region is to more fully develop its renewable energy resources.* | | | | | | | | | | |
| **Quebec and Climate Change: A Challenge for the Future** | Cross-Sectoral | Policy | Implemented | Provincial | Quebec | | | | | |
| *This 2006-2012 action plan aims to reduce GHG emissions by 6% below 1990 levels by 2012. This plan includes 26 measures that require an estimated $1.5 billion in investments over six years. The plan focuses on the sectors of energy, transport, municipalities, the industrial sector, residual materials, agriculture, health, public security, the environment, natural resources and the territory. The plan consists of more than 20 assistance programs, different awareness initiatives, and new regulatory and legislative measures.* | | | | | | | | | | |
| **Government Plan to Reduce the Use of Heavy Fuel Oil** | Energy | Policy | Implemented | Provincial | Quebec | | | | | |
| *The aim of this plan is to improve air quality and reduce GHG emissions. It includes fuel oil energy efficiency measures, measures to encourage cleaner energy alternatives and tightened fuel oil sulphur level standards.* | | | | | | | | | | |
| **Quebec Public Transit Policy** | Transport | Policy | Implemented | Provincial | Quebec | | | | | |
| *Part of Quebec's action plan, this is aimed at increasing public transit use by 8% by 2012. In Quebec, 40% of GHG emissions are attributable to the transportation sector. This policy includes seven assistance programs aimed at supporting the development of public transit and alternative means of transportation in Quebec.* | | | | | | | | | | |
| **Quebec-Ontario Partnership for a Cap-and-Trade Emissions System** | Cross-Sectoral | Economic | Adopted | Provincial | Quebec, Ontario | | | | | |
| *In 2008, Quebec and Ontario agreed to participate in the implementation of a cap-and-trade GHG emissions system.* | | | | | | | | | | |
| **Climate Alliance** | Cross-Sectoral | Policy | Implemented | Provincial | Quebec | | | | | |
| *Climate Alliance is an international network of federated states and regional leaders who support the implementation of concrete climate change mitigation measures by sub-national governments. Officially created in 2006, Climate Alliance emerged from the 11th Conference of the Parties (COP) in Montreal, in 2005. Climate Alliance holds its meetings during COPs.* | | | | | | | | | | |
| **International Carbon Action Partnership** | Cross-Sectoral | Policy | Implemented | Provincial | Quebec | | | | | |
| *During the Poznan conference in December 2008, Quebec announced that it had joined the International Carbon Action Partnership, a coalition of North American and European governments that supports the global carbon marketplace as a tool in the fight against climate change.* | | | | | | | | | | |
| **Regulation on Emission Standards for Light-Duty Vehicles** | Transport | Regulatory | Implemented | Provincial | Quebec | | | | | |
| *The Regulation applies to the fleet of light-duty vehicles and light-duty trucks during the 2010 to 2016 model years sold, rented or put on the market in Quebec. Car manufacturers will be required to ensure, for each of these model years, that the average GHG emission of their entire fleet does not exceed prescribed standards. Standards adopted by Quebec are the same as those in effect in California and in more than a dozen other US states.* | | | | | | | | | | |
| **Quebec Energy Strategy 2006-2015** | Energy | Policy | Implemented | Provincial | Quebec | | | | | |

Table A.6: Policies and Measures (continued on next page...)

| Policy or Measure | Sector | Type of Instrument | Status | Level of Government | Implementing Entity | Estimate of Mitigation Impact | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| | *This strategy, based on the development of renewable energy (hydroelectricity, wind and biomass), targets a more efficient use of all forms of energy. To improve energy efficiency, energy-saving targets are established for the different sources of supply.* | | | | | | | | | |
| **Plan for Energy Efficiency and New Technologies** | Energy | Policy | Implemented | Provincial | Quebec | | | | | |
| | *The plan includes various initiatives aimed at improving energy efficiency as regards the use of fossil fuels, particularly in the transport sector. The plan aims to achieve energy savings of two million tonnes of oil equivalent in 2015, which is a first in this sector.* | | | | | | | | | |
| **Development Strategy for Quebec's Environmental and Green Technology Industry** | Industry | Policy | Implemented | Provincial | Quebec | | | | | |
| | *The purpose of the strategy is to combine economic development with the achievement of environmental objectives, namely in reducing greenhouse gases, and to make the industry an international beacon of innovation. The strategy possesses a budget of more than $280 million.* | | | | | | | | | |
| **Wood Use Strategy for Construction in Quebec** | Forestry | Policy | Implemented | Provincial | Quebec | | | | | |
| | *The objective of the strategy, whose budget is $16 million, is to increase the use of wood in multifamily and nonresidential construction in Quebec.* | | | | | | | | | |
| **Duty on Gasoline and Fossil Fuels** | Cross-Sectoral | Regulatory | Implemented | Provincial | Quebec | | | | | |
| | *In order to finance its Climate Change Action Plan, the Government of Quebec developed a duty on gasoline and fossil fuels in October 2007. The duty applies to distributors of gasoline and fossil fuel used for energy efficiency purposes and is calculated based on GHG by type of energy.* | | | | | | | | | |
| **Action Plan for Developing the Value of Forest Biomass** | Forestry | Policy | Implemented | Provincial | Quebec | | | | | |
| | *The purpose of this plan is to replace polluting energies with energy that is clean and renewable, thereby reducing GHG emissions. Development of the biofuel sector is also planned.* | | | | | | | | | |

Table A.6: Policies and Measures

## A.3 Description of selected projects or programmes that promoted practicable steps to facilitate and/or finance the transfer of, or access to, environmentally-sound technologies

**Project/programme title:** CFS Carbon Knowledge and Tools Available to Stakeholders

**Purpose:** To transfer knowledge and expertise in the use and application of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) to national and international forestry community.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| International | Forest | $300,000 | 2001-2009 |

**Description:** In 2002, the carbon accounting team of the CFS (CFS-CAT) and the Canadian Model Forest Network (CMFN) responded to the forest industry's need for an operational carbon accounting tool. The tool would help forest managers meet criteria and indicator reporting requirements for sustainable forest management as well as reporting requirements for forest certification. It would help managers understand how their actions affect the net carbon balance of their forest estate. The CBM-CFS3 is a stand- and landscape-level modeling framework that simulates the dynamics of all forest carbon stocks required under the UNFCCC. It is compliant with the Good Practice Guidance for Land use, Land-use Change and Forestry (2003) report published by the IPCC. The freely available operational-scale CBM-CFS3 is the most widely-used forest carbon model in Canada. It is used by industry, governments, ENGO's, and academia in Canada.

In 2005, NRCan began a bilateral project with the Russian Federal Forest Agency to share knowledge and approaches to forest carbon accounting with scientists in Russia where the model has been used for regional- and national-scale analyses. More recently, the CFS-CAT began a collaborative project with CONAFOR (Comisión Nacional Forestal), the Government of Mexico's Ministry of Forests, to assess and test the suitability of the CBM-CFS3 in the wide range of forests and climates of that country. The aim of the project is to determine whether the model could contribute towards Mexico's GHG accounting system and towards Mexico's efforts to account for the effects of reducing emissions from deforestation and degradation (REDD). More recently, the CFS-CAT has also begun collaborating with individuals in Spain, China, Italy and potentially, Korea.

**Indicate factors which led to project's success:**

- Partnership between the organization developing the science and technology (NRCan, CFS), and a nationwide organization with an established network of partners in the operational forestry community (the CMFN).
- Knowledge and expertise of the teams involved.
- Use of the CBM-CFS3 as the main model in Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS).
- Promotion of published scientific research using the CBM-CFS3.
- National and international promotion of the CBM-CFS3.
- Successfully executing several training workshops for national and international participants at low cost to participants.
- Free model, documentation, and technical support for model users.
- Web resources facilitating information exchange (project website, NRCan FTP sites, Canada National Forest Information System website)

Table A.7: CFS Carbon Knowledge and Tools Available to Stakeholders (continued on next page...)

**Technology transferred:**

- **The CBM-CFS3 software and supporting documentation (user's guide and tutorials)**. over 500 individuals in 42 countries have obtained the software to date, and it is being used by individuals around the world.
- **Knowledge and expertise in the use of the CBM-CFS3**. 9 training workshops have been held in Canada to date, training 223 participants, 33 from foreign countries (including the Russian Federation and developing countries like Madagascar, Uganda, Thailand, Philippines, Mexico, and China). 3 training workshops were held between February 2006 and February 2009. 2 more training workshops were held after February 2009. A mini-CBM-CFS3 training workshop (1/2 day) was also presented at the International Model Forest Global Forum (IMFN) in Hinton, Alberta in June 2007.
- **Information and assistance**. Between February 2007 and February 2009, the project extension forester provided free technical support to CBM-CFS3 users, responded to nearly 600 requests for assistance and guidance from around the world.
- **Collaboration with Russia:**. in March 2005, a member of the Russian Academy of Sciences attended a CBM-CFS3 training workshop. In 2006, the Russian Academy of Science sent one of their staff to work with the CFS-CAT for 2 months to learn how to use and apply the CBM-CFS3 to forests in Russia. The same individual met with the team again at PFC in February 2009, to finalize a project involving the application of the CBM-CFS3 to Russian forests at the national scale, as Canada does under NFCMARS. Collaboration, information exchange and use of the CBM-CFS3 continues.
- **Collaboration with Mexico:**. A workshop was held between NRCan, CONAFOR and ECOSUR in Mexico in June 2008 to exchange information on forest carbon accounting and carbon accounting technology. In March 2009, 6 individuals from the above Mexican organizations and the Colegio de Postgraduados, participated in a CBM-CFS3 training workshop at the Pacific Forestry Centre, followed by a one-day meeting to exchange information on forests, carbon accounting and modeling issues, etc. Collaboration, information exchange and use of the CBM-CFS3 continues.
- **Collaboration with Spain:**. As a result of the CBM-CFS3 mini-workshop in Hinton in 2007, 2 individuals from the Spanish Dirección General de Medio Natural y Pol"tica Forestal and 1 individual from CESEFOR attended the CBM-CFS3 training workshop in March 2009. All three individuals also participated in an additional day of forest and carbon accounting information exchange with the CFS-CAT. In July 2009, the individual from CESEFOR returned to Pacific Forestry Centre for almost 2 months to work with the CFS-CAT to test applying the CBM-CFS3 to Spanish forest data. Collaboration, information exchange and use of the CBM-CFS3 continues.
- **Collaboration with China:** . In January 2007, an individual from the Chinese Academy of Sciences attended a CBM-CFS3 training workshop. This individual sent a colleague to the March 2009 CBM-CFS3 training workshop, and she also participated in an additional day of forest and carbon accounting information exchange with the CFS-CAT. Further collaboration, information exchange and use of the CBM-CFS3 continues.
- **Collaboration with Italy and Korea:** . In July 2009, one individual from the Joint Research Centre (Italy), and one individual from Kookmin University (Korea), attended a CBM-CFS3 training workshop. Both participated in an additional half-day of forest and carbon accounting information exchange with the CFS-CAT. Although preliminary, further collaboration and information exchange will likely occur, and the individual in Italy has begun testing the model with their data.

Table A.7: CFS Carbon Knowledge and Tools Available to Stakeholders

**Project/programme title:** Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD)

**Purpose:** The GOFC-GOLD Implementation Project provides leadership and support to ensure a systematic long-term program of space-based and on the ground observations of land cover and forest change, including the role of fire.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| International | Forest | CAD 900K/year contributed by 6 international sponsors (incl. $300K/year from CFS and CSA) | 1999-present |

**Description:** GOFC-GOLD is a coordinated international effort to ensure a systematic long-term program of space-based and on-the-ground observations of land cover and forest change, including the role of fire. It is designed to help provide the data needed for global monitoring of terrestrial resources, study of global change, and improved natural resources management. As a panel of the Global Terrestrial Observing System (GTOS), GOFC-GOLD interacts with several United Nations bodies and numerous international and national scientific and technical organizations. It develops contributory products at regional and global scales in two thematic areas: Land Cover Characteristics and Change; and Fire Monitoring and Mapping. A new biomass mapping theme is being developed.

By promoting and supporting participation on implementation teams and in regional networks, GOFC-GOLD provides the international coordination to articulate user needs, specify requirements for products, assess algorithms and data assimilation procedures, and develop harmonization protocols and standards. It also provides information to support international assessments and protocols. Capacity is strengthened by working with regional networks, which provide guidance on regional needs and promote the transfer of technology and experience in South East Asia, Central, Western and Southern Africa, Northern Eurasia, Latin America, and East Asia. GOFC-GOLD also acts as an independent forum to advocate for the continuity of observations and their validation and availability.

GOFC-GOLD initially focused on defining the requirements for observational products and their specifications. More recently, GOFC-GOLD has also directed its efforts towards addressing the needs for terrestrial observations for the following initiatives:

- International environmental conventions such as United Nations Framework Convention on Climate Change (UNFCCC), including methods and procedures for monitoring, measuring and reporting on reducing greenhouse gas emissions from deforestation and degradation in developing countries.
- Implementation Plan for the Global Climate Observing System (GCOS IP).
- Land theme of the Integrated Global Observing Strategy Partnership (IGOL).
- Societal benefit areas of the 10-year work plan towards a Global Earth Observation System of Systems (GEOSS).
- Proposed international land earth observation satellite network composed of multiple satellites with 30-m (or better) capabilities.

The GOFC-GOLD Project Office is located in Canada and is hosted by Natural Resources Canada's Canadian Forest Service and the Canadian Space Agency.

**Indicate factors which led to project's success:**
During the 2006-2009 project period there were 92 cumulative GOFC-GOLD sponsored and co-sponsored events including technical seminars, workshops, missions, meetings and training courses held internationally and in Canada. In addition, with CFS Project Office support, the Implementation Teams and Regional Networks produced and released 40 documents during the reporting period. The events and document production mentioned above provided opportunities for GOFC-GOLD outreach to approximately 4765 people during the reporting period. The Implementation Project engaged 55 Canadian specialists and officials from nine organizations with an interest in the Earth Observation functions of GOFC-GOLD.

Table A.8: Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) (continued on next page...)

**Technology transferred:**

**Collaboration with China:** As part of a 2007 APEC Summit commitment, China is leading the development of the Asia-Pacific Network on Forest Monitoring. In support of the GOFC-GOLD East Asia Regional Network, the Project Office is supporting the Chinese State Forest Administration in developing the Asia-Pacific Forest Monitoring Network as a contribution to the China-led Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet). The Project Office has co-organized a series of workshops in China, providing technical presentations and providing travel support for participants from Southeast Asia to attend. Results of the workshops are included in the APFNet progress reports delivered by China at APEC Ministers meetings.

**Forest Carbon Tracking task of the international Group on Earth Observations (GEO):** The Project Office is collaborating with the Canadian Space Agency (CSA) to support this task to improve global monitoring of reducing emissions from deforestation and forestation (REDD). The task is demonstrating that Earth observations can be acquired in a planned and systematic manner and be used for forest carbon tracking in the post 2012 framework of the UNFCCC. The forest carbon tracking task will be highlighted at the 2009 GEO Plenary at Washington, DC. The White House Office of Science and Technology Policy (OSTP) is following the task closely in relation to the forest offset component of new energy and climate bill now being debated in the senate. The Project Office will attend as part of Canada's delegation led by EC.

**Task collaboration with Mexico** - Specifically, the Project Office acts as a task co-lead and is collaborating with the Mexico REDD Committee to support Mexico's involvement in the task as a national demonstrator. The effort compliments the CFS Carbon Accounting team's collaboration with Mexico to transfer the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3). Activities include meetings and workshops with the Mexico REDD Committee. The Project Office has presented information on the GEO forest task and held technical discussions on Mexico national demonstrator activities.

**Task collaboration with international space agencies** - With Project Office support, the CSA is providing its Radarsat 1 and 2 data to seven national demonstrator countries, including Mexico. As well, it is leading the data acquisition coordination for the radar data to be provided by several space agencies (CSA, ESA, JAXA, etc.).

Task collaboration with international organizations - Several task meetings and workshops were held in 2008 and 2009 in partnership with several international organizations including the Prince's Rainforest Project, Google Foundation, UN-REDD Programme and Clinton Foundation. The events reviewed strategies for the implementation of forest carbon monitoring, reporting and verification, and identified collaborative opportunities. The Project Office has provided technical presentations and travel support for participant to attend from developing countries.

**Collaboration with Argentina:** The Aquarius/SAC-D satellite mission involves Argentina, the United States, Italy, Canada, France and Brazil, to launch a satellite observatory. A series of workshops were help during the reporting period to bring together the International Aquarius/SAC-D Science Team. Canada's Wildland Fire Information System (which produces annual estimates of Carbon emissions from forest fires) will benefit from the mission by receiving thermal infra-red data from one instrument, the New Infra-Red Sensor Technology (NIRST).

**Sourcebook of measurement and monitoring methodologies for REDD:** Provides a consensus perspective from the global community of earth observation and carbon experts on methodological issues relating to quantifying the green house gas (GHG) impacts of implementing activities to reduce emissions from deforestation and degradation in developing countries (REDD) (http://www.gofc-gold.uni-jena.de/redd/index.php). Based on the current status of negotiations and UNFCCC approved methodologies, the Sourcebook aims to provide additional explanation, clarification, and methodologies to support REDD early actions and readiness mechanisms for building national REDD monitoring systems. It emphasizes the role of satellite remote sensing as an important tool for monitoring changes in forest cover, and provides clarification on applying the IPCC Guidelines for reporting changes in forest carbon stocks at the national level. The Sourcebook includes a description of Canada's CBM-CFS3. The Project Office supports the GOFC-GOLD Sourcebook working Group. It is printing a brochure and CD of the new version of the Sourcebook for distribution at side events and forest learning days at the UNFCCC CoP-15, Copenhagen.

**Central Africa Regional GOFC-GOLD network:** OSFAC (Observatoire Satellital des For'ts d'Afrique Centrale, http://osfac.umd.edu/index.htm) works to improve the quality and availability of satellite observations of forest and land cover in the Congo Basin and to produce useful and timely information products for a wide variety of users. An OSFAC Regional workshop and Carbon REDD meeting is planned for late 2009 at Kinshasa. The event will involve the OSFAC member countries including Cameroon where the CFS IMFN Secretariat is supporting an African Model Forest Initiative. The Project Office is providing technical presentations and travel support for participants from OSFAC network countries and GOFC-GOLD Implementation Team specialists to attend.

**Africa Pilot of the GOFC-GOLD Regional Network Data Initiative:** The Initiative has a developing country emphasis and takes advantage of the data recently made available through the opening up of the USGS Landsat archive. Its goals are to: 1) disseminate Landsat data to the international science community in regions where currently available distribution methods are not effective; 2) compile regional and country-level data sets relevant to land cover and fire observations and make them freely available to the community of users in the regions; and 3) engage regional science expertise in the global data set development, evaluation, and validation. The first initiative took place in 2008 and involved data specialists from the regional networks: OSFAC (Central Africa Regional Network); SAFNET (Southern Africa Regional Fire Network); WARN (West Africa Regional Network); East Africa Regional network (emerging, initiated by Sudan); and Miombo (Miombo Regional Network). Based on the results of the Africa pilot, further initiatives will be undertaken for the other GOFC-GOLD regional networks, including NERIN (Northern Eurasia), SEARRIN (Southeast Asia), RedLatif (Latin America) and emerging networks in Amazon and East Asia.

Table A.8: Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD)

**Project/programme title:** Developing Critical Mass for micro Combined Heat and Power Systems – APP Project

**Purpose:** This project will consolidate current field trials experiences in Japan, U.S. and Canada and extract lessons learned on energy and GHG impacts of micro CHP, and diffuse to other APP countries.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Canada, Japan, and United States | Energy | $500,000 over 3 years (GoC Contribution) Private Sector Leverage: $3M | 2009-2012 |

**Description:** The objectives of the project are to:

- consolidate the current field trials experiences in Japan, the US and Canada and extract lessons learned and energy and GHG impacts of micro CHP.
- transfer these experiences to other APP countries

These experiences will be documented through a combination of workshops on the subject to share current experiences and future activities. A "lessons learned" of Canadian, US and Japanese experiences report for consumption by APP member countries will also be produced.
Based on these experiences, a limited field trials demonstration will subsequently be undertaken in those APP countries where micro CHP is still immature. Priority countries will include India and China. Primary technologies will be drawn from Japan, combined with value-added technological input from Canada and the US. The objective will be to help other APP countries reach the same level of sophistication with regard to micro CHP as that of Canada, US and Japan

**Indicate factors which led to project's success:**
This project has just been initiated.

**Technology transferred:**
Combined heat and power systems are a form of cogeneration that is defined as the simultaneous production of heat and power which is normally referred to as CHP (combined heat and power). CHP systems can be as small as an "appliance" located inside a single family home or small business or at the larger end of the spectrum of potential applications systems could be single or multiple internal combustion engines serving a multi-unit apartment building, retirement residence, community center, farm or industrial facility. Technologies include natural gas internal combustion engines to next generation fuel cells.

Mature CHP technologies would typically replace the conventional furnace/boiler and hot water tank of a typical residence at comparable cost thus providing all heating and hot water needs and a portion of the electricity needs. During some portions of the day, the electricity could be fed back to the grid.

Cogeneration allows the end user to participate directly in the decision to invest in electricity production, which can serve both the customer and the utility in terms of demand side management, emergency power, reliability, and energy conservation.

For Canada, and its goals for improvements in the supply and delivery of energy, a distributed power strategy that involves distributed micro-cogeneration systems offer Canadians several important benefits, including:

- Reduced primary energy consumption
- Reduced GHG and CAC emissions, especially when coal is displaced
- Reduced electricity distribution system losses
- Contribution to improved power quality/reliability
- Contribution to avoidance of demand charges and peak pricing
- Support for conservation and demand side management programs

These benefits are applicable to all APP member countries.
Small scale CHP (residential or light commercial) are receiving significant attention in Canada, Japan and the US. Japan is one of the leaders in developing the small scale CHP market, with products now reaching a degree of maturity in Japan making them ready for larger scale deployment.
The US is already scaling up for limited field trials of a natural gas based micro CHP unit (1kW) based on a Honda CHP platform from Japan. Honda has partnered with Climate Energy of the US who has provided value-added engineering to adapt the product for North American market.
Enbridge have also committed to field trials of a similar unit in Ontario and Saskatchewan Energy is now exploring a field trial project of CHP for Saskatchewan. Entrepreneurial Canadian companies are beginning to explore the development of the business model for providing value-added components for Canadian adaptation (controls, cold temperature inverters, grid connections, thermal storage, ability to automatically start when the grid fails).
Japan is also now launching market ready deployment initiative for residential scale fuel cells. Ballard, a major supplier of fuel cell stacks to Ebara, a Japanese fuel cell company, is now looking at the market potential for residential fuel cells in Canada and other markets.
Through existing bilaterals Canada, the US and Japan have identified the area of residential scale combined heat and power (CHP) as a theme of mutual interest to both countries. Technologies under this theme include both conventional natural gas engines and fuel cells.

Table A.9: Developing Critical Mass for micro Combined Heat and Power Systems – APP Project

**Project/programme title:** International Net-Zero Energy Homes (NZEH) Coalition Project - APP Project

**Purpose:** Establish an Industry led International NZEH Coalition to support member's national efforts and accelerate the adoption of NZEH.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Australia, Canada, China, Japan, Korea and the United States | Housing, Energy | $500,000 over 3 years (GoC), $24 M private Sector Leverage | 2009-2012 |

**Description:** This project seeks to establish an International Net Zero Energy Home Coalition (NZEH) or an International NZEH Dialogue. As part of this project, Partners will initiate a collaborative dialogue to establish a formal international partnership that will map the path to achieving NZEH.

**Indicate factors which led to project's success:**
This project has just been initiated.

**Technology transferred:**
Energy efficiency, indoor air quality, and ventilation and building envelope durability. Emerging themes of mutual interest include net-zero housing, residential scale combined heat and power, and district energy systems.

Through a series of workshops and collaborative sessions, Partners will also seek to set a precedent for housing performance optimization by bringing together the fragmented supply chain involving this sector and discuss issues and industry barriers. The workshops will prominently feature industry, case studies, R&D and demonstrations. This holistic approach will differentiate Partners as global leaders in the design and development of energy-efficient housing. Collaboration will accelerate the identification of optimal solutions and improve conditions for innovation.

For example, the Canada-Japan Housing Research and Development (R&D) Workshop is a longstanding housing technology bilateral agreement between the Building Research Institute (BRI) of Japan and CanmetENERGY (NRCan). Participants are from industry, universities and other government research departments including the National Research Council's Institute for Research in Construction and the Canada Mortgage and Housing Corporation, and organizations such as the Institute for Building Energy Conservation in Japan.

Table A.10: International Net-Zero Energy Homes (NZEH) Coalition Project - APP Project

**Project/programme title:** Investigation for Demonstration of Plasma Ignition System - APP Project

**Purpose:** This project aims to implement plasma systems for the Canadian power sector in order to enhance energy efficiency and reduce emissions.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Australia, Canada, China, India, Japan, Korea and the United States | Energy generation | $350,000 over 3 years (GoC contribution), Private Sector Leverage: $755,000 | 2009-2012 |

**Description:** In this activity, China will host a series of site visits to demonstrate plasma ignition technology, which can directly ignite pulverized coal, thereby replacing fuel oil and ensuring ignition and stable combustion for pulverized-coal boilers in an energy-efficient manner.

**Indicate factors which led to project's success:**
This project has just been initiated

**Technology transferred:**
China Guodian will host a series of site visits regarding the plasma ignition technology to highlight reliable energy conservation and environment protection technology and its application in China. The goal of the project is to help power generators learn the benefit of the plasma technology.
*Plasma Ignition and Combustion Stabilization System:* Directly igniting pulverized coal, the system can replace fuel oil and ensure ignition and stable combustion for pulverized-coal boilers. This system has found successful application in 270 of pulverized-coal boilers, with coals covering lean coal, bituminous coal and lignite; unit capacity of 50MW-1000MW, both tangential-fired and wall-fired types; milling systems including indirect-fired and direct-fired types; mills including spheroidal roller mill, ring-roller mill, ball race mill with double inletsand outlets, roller pulverizer, and fan mill, etc.

Table A.11: Investigation for Demonstration of Plasma Ignition System - APP Project

**Project/programme title:** Magnesium Front End Research and Development Project

**Purpose:** The objective of this five-year, three-nation undertaking is to develop a magnesium-intensive front end for an automobile. Lightweight materials technologies play a crucial role in efforts worldwide to increase energy efficiency and reduce emissions from automobiles.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Canada, People's Republic of China, United States of America | Minerals and Metals Sector | US$22 million | 2007-2012 |

**Description:** The Magnesium Front End Research and Development project, or MFERD, is a multi-task research effort involving Natural Resources Canada (NRCan), China's Ministry of Science and Technology, and the United States Department of Energy. NRCan's CANMET Materials Technology Laboratory (CANMET-MTL) is the Canadian coordinating organization for the MFERD project, which involves three Canadian companies, the National Research Council of Canada, and five universities.

**Indicate factors which led to project's success:**
Collaboration among government, academic, and private-sector partners is the principal reason for the ongoing success of the MFERD project. During Phase I of the project, a magnesium-intensive front end was designed that is 38 kilograms lighter (45 percent) than a typical front-end steel structure. A demonstration front end will be built and validated during Phase II, which begins in 2010.

**Technology transferred:**
High-vacuum die casting, sheet forming, and technologies for joining dissimilar metals. The mechanism of transfer is through workshops held on an annual basis for researchers and engineers from the three countries.

Table A.12: Magnesium Front End Research and Development Project

**Project/programme title:** Development of next generation of nuclear power reactors

**Purpose:** R&D collaboration to accelerate development of the next generation of nuclear power reactors

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Partners include Canada, U.S., France, EU, Switzerland, China, Korea, Japan, South Africa | Energy (nuclear power) | $4.8M | |

**Description:** The Generation IV International Forum is a multi-lateral organization for R&D to develop the next generation of sustainable nuclear energy systems for commercialization in the 2025-2030 timeframe. All leading nuclear nations participate including: U.S., France, Japan and the EU. 20 Canadian universities are also involved and have leveraged additional funding.

**Indicate factors which led to project's success:**
This project is not yet completed. Through cooperation, the participating countries are looking to share costs and accelerate the timelines of the R&D so that secure and sustainable nuclear technologies will be available sooner.

**Technology transferred:**
Next generation nuclear energy systems, specifically, the Supercritical Water-Cooled Reactor (SCWR) and the Very-high Temperature Reactor (VHTR). New reactors are hoped for post 2030.

Table A.13: Development of next generation of nuclear power reactors

**Project/programme title:** VLH turbine collaboration

**Purpose:** To demonstrate the economic viability, energy efficiency and fish friendliness of the Very Low Head turbine technology for very low-head small hydro applications (heads less than 3 meters) in Canada and the United States of America.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| U.S., Canada | Energy (hydro power) | $610,000 (GoC, includes in-kind) $2,190,000 (CDN project partner leveraging) $1,180,000 (US contribution) | 2009-11 |

**Description:** Under the Security and Prosperity Partnership, Canada and the United States of America are collaborating on research aimed to advancing very low head hydropower technology and its applications.
The Very Low Head Turbine, owned by MJ2 Technologies S.A.R.L. of France, is an innovative and cost-effective technology that allows the development low head hydro sites with very limited impact on environment. This clean, renewable technology was collaboratively developed by Canada and France.
Although Canada and USA have significant very low head hydro potential (over 1100 MW), only a small percentage of it has been developed, mainly because the sites are not economical to develop with existing low head technology. In addition, the lack of development of the technology is associated with two other key challenges: the environmental mitigation and regulatory requirements associated with all hydropower projects. This project will focus on: 1) the demonstration of the VLH technology on a Canadian site with about 500 kW of installed capacity, and, 2) the engineering studies for the VLH turbine system and selected sites in Canada and USA. In Canada, the project team has identified several sites that have good potential for the demonstration purpose and will determine a best one for the demonstration purpose; in the USA, a site identified on the Mississippi River will be used for the engineering studies purpose. The information and experience accumulated throughout the implementation of the VLH turbine technology in Canada, as well as the results of engineering studies will be shared with engineering firms, sites developers and participating government agencies in Canada, USA and Mexico through regular meetings and a final trilateral workshop for the project.

**Indicate factors which led to project's success:**
This project is ongoing

**Technology transferred:**
Very Low Head Hydraulic Turbine

Table A.14: VLH turbine collaboration

**Project/programme title:** TEAM (Technology Early Action Measures)

**Purpose:** Transfer greenhouse gas reduction technologies to other countries. TEAM brought 140 technology demonstration projects to reality in Canada and around the world.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Various | Various | $128 M | 1998-2009 |

**Description:** TEAM supported the transfer of innovative Canadian GHG reduction technologies to other countries, particularly developing nations. TEAM has demonstrated that the best opportunities for benefiting from new technologies in international development require risk sharing among business and government partners in developed and developing countries.
A number of projects occurred in the 2006-2008 timeframe and are listed below, with total project costs in brackets: **Hydropower in Nepal ($8.30 M)** Development of a small-hydro plant at a site on the Khudi River 150 kilometres from Kathmandu, Nepal, that will generate over 25,000 MWh a year. The plant replaced thermal generation and extended electricity distribution to a population that relied on wood fuel and residues for its energy.
**Natural gas vehicle flagship project in India ($8.33 M)**

- Demonstration of Canadian natural gas vehicle technologies in India.
- Conversion of 250 commercial fleet light duty vehicles to natural gas; low emission natural gas engines and low weight natural gas storage on six transit and intercity buses
- This project also documented the feasibility of GHG credit repatriation to help meet Canada's Kyoto commitments.

**Energy-efficient chiller systems for Cuba ($2.3 M)** This project involves installing 8 to 10 high-efficiency Smardt chillers as an alternative to older, inefficient chillers in Cuban hospitals, office buildings and commercial buildings. These chillers consume significantly less energy than conventional centrifugal chillers and do not use chlorofluorocarbons.
**Demonstration of EcoSmart Concrete in Dubai ($2.4 M)** A high-profile international demonstration project for EcoSmart concrete technology in the booming United Arab Emirates construction market. In EcoSmart concrete, ordinary Portland cement is partially replaced by supplementary cementing materials, which creates a more durable concrete and reduces solid waste and GHG emissions.
**Small Scale Biogas Utilization in Argentina ($4.4 M)**

- Demonstrate use of remote monitoring and control system on two biogas utilization and conversion projects in Argentina: a wastewater treatment facility and a landfill site. The biogas will be used to generate electricity and produce heat
- Innovation consists of using a telemetry system to reduce operations & maintenance costs for small & medium scale biogas systems, via use of telemetry-based control system.

**Transportable Plasma Waste to Energy System ($7.6 M)** Demonstrate innovative 10 ton-per-day transportable plasma resource recovery system at a US military facility. System uses a wide range of waste streams - including municipal solid waste, hazardous waste and hospital waste - to generate electricity, heat, aggregate for construction, and metals for recycling.

**Indicate factors which led to project's success:**
Innovative reporting tools An important element of the TEAM program is the commitment to report the technical performance and GHG mitigation potential of all TEAM-funded projects. TEAM's pioneering work in the development of tools and methodologies for measuring and reporting GHG reductions has resulted in the System of Measurement and Reporting for Technologies (SMART). SMART provides a basis to evaluate the project proponent's processes and documentation so that the technological performance claims and the GHG mitigation potential can be substantiated. Since 2004, all TEAM projects followed the SMART process.
TEAM staff have continued to play a leading role in providing internationally accepted standards in GHG measurement and reporting. For example, TEAM's SMART protocol led to the creation of ISO 14064 Part 2. These ISO standards will help GHG programs ensure global credibility and consistency.
Leveraging funding TEAM has funded 140 climate change and clean energy projects since its inception in 1998. However, the federal government investment represents only a small portion of the total funding required for these projects. For every dollar invested by TEAM and the Canadian federal government, five dollars are invested by TEAM's partners, including small and large companies, both in Canada and abroad, and other federal, provincial, municipal and foreign government agencies. In more than 60 Canadian cities and 15 countries, TEAM has partnered with approximately 350 private companies and organizations, and with more than 100 government programs and research institutions.

**Technology transferred:**
Hydropower in Nepal: small hydro generation Natural gas vehicle flagship project in India: compressed natural gas technologies for vehicles Energy-efficient chiller systems for Cuba: energy-efficient, CFC-free chillers Demonstration of EcoSmart Concrete in Dubai: EcoSmart concrete Small Scale Biogas Utilization in Argentina: remote monitoring; telemetry-based control system Transportable Plasma Waste to Energy System: plasma waste to energy technology

Table A.15: TEAM (Technology Early Action Measures)

**Project/programme title:** IEA GHG Weyburn-Midale CO2 Monitoring and Storage Project

**Purpose:** To develop and demonstrate carbon capture and storage technology.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Partners include: Japan and the US | Construction | $12.75 M | 2000-2011 |

**Description:** Launched in 2000 and scheduled to be completed in 2011, this 11-year $80 million international project studies CO2 injection and underground storage in conjunction with two commercial $CO_2$- enhanced oil recovery operations at Weyburn-Midale. Currently in its Final Phase (2005-2011), the project is building on the successes of the First Phase (2000 - 2004) to deliver the framework necessary to encourage implementation of $CO_2$ geological storage on a worldwide basis. The Final Phase will deliver comprehensive science and engineering data, which will be used for the development of publicly-accepted, regulatory-approved, site-insensitive and cost-effective industrial protocols for site selection, design, operation, risk assessment, monitoring, and qualitative and reliable verification of $CO_2$ storage volumes. These protocols will be the main elements of the Best Practices Manual, which will be the key deliverable of the project. In parallel and in close integration with the above, policy activities will be undertaken comprising the development of a public communications plan, advice on regulatory frameworks, and advice on the economic environment and market/fiscal incentives.

**Indicate factors which led to project's success:**
This project is ongoing

**Technology transferred:**
Long-term subsurface storage of carbon dioxide. Development of state-of-the-art $CO_2$ measurement, monitoring and verification technologies.

Table A.16: IEA GHG Weyburn-Midale CO2 Monitoring and Storage Project

**Project/programme title:** Transferring Small Hydro Technologies to China Project

**Purpose:** To demonstrate the effectiveness of Canadian small hydropower technologies in providing and enhancing small hydropower as a viable alternative to other energy sources in China.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| China | Energy (small hydro) | $2 Million | 2002-06 |

**Description:** The "Transferring Small Hydro Technologies to China" project was a collaborative public-private project, including 5 Canadian industry partners and one international organization.
Natural Resources Canada worked bilaterally with China's Ministry of Water Resources. The project demonstrated the effectiveness of Canadian technologies in providing and enhancing small hydro power as a viable alternative to other energy sources in China, such as coal. This project focused on introducing Canadian technologies into rural Chinese small hydro plants to demonstrate effectiveness, efficiency gains and economic returns. In turn, this enhanced viability results in an increased and more stable supply of clean electricity to communities to drive sustainable economic development.

**Indicate factors which led to project's success:**

- Funding provided under Canada's Climate Change Development Fund (CIDA).
- Cooperative science and technology exchange relations between Canada and China, as illustrated through a Memorandum of Understanding signed between Natural Resources Canada and China's Ministry of Water Resources in 2005.

**Technology transferred:**
Technologies transferred include small hydro automation, river basin optimization systems, enhanced turbine design, and mini and micro hydro systems. Capacity building complimented the technical work.

Table A.17: Transferring Small Hydro Technologies to China Project

**Project/programme title:** Marine Energy: Optimization of Next Generation Commercial Kinetic Hydropower System

**Purpose:** To develop an optimal electricity generation and interconnection subsystem for next-generation commercial kinetic hydropower systems.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| USA, Canada | Energy (Marine) | $460,000 (GoC contribution), $274,800 (CDN partners leveraging) | 2009-2011 |

**Description:** Under the Security and Prosperity Partnership, Canada and the United States of America are collaborating on research aimed to advancing marine renewable energy technology and their applications.
Natural Resources Canada is supporting a partnership between Verdant Power Canada (VPC) and the University of New Brunswick that undertakes a critical examination and development of the electricity generation and interconnection subsystem to VPC's next-generation kinetic hydropower system (KHPS).
This project aligns with Verdant Power's project to optimize the design of their KHPS in collaboration with the National Renewable Energy Laboratory, Sandia National Laboratory, and the U.S. Department of Energy.
The KHPS is designed to generate clean, renewable energy from the currents of rivers and tides without the use of dams.

**Indicate factors which led to project's success:**
This project is ongoing.

**Technology transferred:**

- Kinetic Hydropower Systems and components
- Electricity generation and interconnection subsystems

Table A.18: Marine Energy: Optimization of Next Generation Commercial Kinetic Hydropower System

**Project/programme title:** Reduction of Emissions from Coal-Based Power Generation

**Purpose:** An international partnership between Canada and China was established to reduce emissions from coal-fired utility boilers. A well-tested CFD modeling tool was used to identify the improvement strategies for 11 selected units ranging from 200 to 600 MWe, to realize the reduction of coal consumption, $NO_x$ and $CO_2$ emissions and the increase of availability. The study results could potentially be extended to 23% of the units in China to achieve significant GHG reduction prior to implementing advanced clean coal technologies like IGCC and oxy-coal combustion with $CO_2$ capture.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| China | Energy - Power Generation | $2,000,000 (CIDA) | 2003 to 2006 |

**Description:** The project was a multi-year, bilateral project between CanmetENERGY and the Chinese power generation sector to investigate the extent of improvement that can be made to existing (and not ready to be retired) coal fired boiler units to upgrade existing coal-based power generation units both in Canada and abroad, The novel development of this project was the use of CFD (computational fluid dynamics) via the creation of a user-friendly modeling tool for coal-fired utility boiler, named "CoalFire". Through a graphical user interface, a user can input the physical dimensions of the unit, specify the burner geometry, select the coal type and submit the air and fuel flow rates. Then the software with built-in "artificial intelligence" will automatically generate the computational grid, initiate and complete the computation, and generate a simulation report in a HTML format ready to be issued to power plant operators for diagnostic or performance improvement purposes. "CoalFire" was jointly developed by CanmetENERGY and ANSYS Canada, based on commercial CFD code ANSYS CFX-TASCflow and the experience of CanmetENERGY in coal-fired boiler modeling.

**Indicate factors which led to project's success:**
Long established relationships between key CanmetENERGY staff and the Thermal Power Research Institute (Xı'an, China) the North China Electric Power University (Boading, China) and Northeastern Electric Power Research Institute (Shenyang, China)

**Technology transferred:**
A user friendly CFD tool for analysis of coal-fired utility boilers to reduce diagnostic time and costs, optimize power generation while reducing GHG, NOx and other emissions. This tool is a key component in aa dedicated program to develop clean coal technologies for near zero emissions through an international partnership focusing on improving the performance and reducing the emissions from a representative sample of the current Chinese coal-fired boiler fleet, with the intent to have more replications completed by the Chinese partners.

Table A.19: Reduction of Emissions from Coal-Based Power Generation

**Project/programme title:** Distributed Energy Resources Program

**Purpose:** Improving the economics and conversion energy efficiency in distributed energy systems including related storage, hybrid, and systems technologies.

| Recipient country | Sector | Total funding | Years in operation (date range) |
|---|---|---|---|
| Canada | Residential and Commercial | $5.2 M | 2008 – 2010 |

**Description:** The program of activities can be divided into two major themes:

- Combined Heat and Power (CHP)
- Energy Conversion and Storage

The scale of interest for both themes is:

- Residential applications (approximately 1 to 6 kWe)
- Commercial/Institutional applications (approximately 250 to 500 kWe)

The major themes and scale of interest were chosen based on the growth potential for these technologies in the 5 years from program inception and the long term potential impact if fully deployed in Canada

**Indicate factors which led to project's success:**
Funding from PERD, ecoETI, MDIP
1st International Conference and Workshop on Micro-Cogeneration Technologies and Applications, Ottawa May 2008 (98 delegates; 14 countries); part of our participation in IEA Annex 42.
Collaboration with partners in various levels of government, OGD's, private sector industry and utilities, academia, and associations, internationally and in Canada.
Case studies, pilot and prototype tests and demonstrations through contribution agreements, contracts.

**Technology transferred:**

- IEA Annex 54: Analysis of Micro-generation and Related Energy Technologies in Buildings
- IEA Annex 42: The Simulation of Building Integrated Fuel Cells and Other Cogeneration Systems
- IEA Annex 34: Thermally Driven Heat Pumps for Heating and Cooling
- 1st International Conference and Workshop on Micro-Cogeneration Technologies and Applications
- 14 peer reviewed papers (11 CanmetENERGY, 3 OGD's)
- 16 non-peer reviewed papers CanmetENERGY
- 17 International presentations (12 CanmetENERGY, 5 OGD's)
- 8 client reports; 11 internal technical reports
- Small enterprise in Bells Corners adapted and integrated imported technology for testing and subsequent demonstration project in Saskatchewan

Table A.20: Distributed Energy Resources Program

## A.4 Abbreviations

**AAFC** Agriculture and Agri-Food Canada
**AATSR** Advanced Along Track Scanning Radiometer
**AAU** Assigned Amount Unit
**ACE** Atmospheric Chemistry Experiment
**ACIA** Arctic Climate Impact Assessment
**ADST** Adaptation Decision Support Tool
**AECL** Atomic Energy Canada Limited
**AIRD** Adaptation and Impacts Research Division
**AMDAR** Aircraft Meteorological Data Relay
**AMSD** Adaptation, Mitigation and Sustainable Development
**APEC** Asia-Pacific Economic Cooperation
**APFNet** Asia-Pacific Network for Sustainable Forest Management and Rehabilitation
**APP** Asia-Pacific Partnership on Clean Development and Climate
**AQHI** Air Quality Health Index
**AR4** Fourth Assessment Report, IPCC
**ARC** AGRHYMET Regional Centre
**ARNEWS** Acid Rain National Early Warning System
**ASAI** Atmospheric Science Assessment and Integration
**ASD** Automated Statistical Downscaling
**ASOF** Arctic-Subarctic Ocean Flux
**AVHRR** Advanced Very High Resolution Radiometer
**AVOS** Automated Volunteer Observing Ships
**AZMP** Atlantic Zone Monitoring Program
**B**
**BEARH** Building Environmental Aboriginal Human Resources
**BERMS** Boreal Ecosystem Research and Monitoring Sites
**BOREAS** Boreal Ecosystem - Atmosphere Study
**BRI** Building Research Institute, Japan
**C**
**C** Carbon
**C5** Canada-China Cooperation in Climate Change
**CAA** Clean Air Agenda
**CAC** Criteria Air Contaminant
**CAFC** Cloud-Aerosol Feedbacks and Climate
**CALM** Circumpolar Active Layer Monitoring
**CANDAC** Canadian Network for the Detection of Atmospheric Change
**CANDU** CANada Deuterium Uranium
**CanESM1** Canadian Earth System Model
**CanFI** National Forest Inventory, existing
**CAPMoN** Canadian Air and Precipitation Monitoring Network
**CARICOM** Carribean Community
**CASES** Canadian Arctic Shelf Exchange Study
**CBM-CFS3** Carbon Budget Model of the Canadian Forest Sector
**CCAA** Climate Change Adaptation in Africa
**CCAF** Canadian Comprehensive Auditing Foundation
**CCCDF** Canada Climate Change Development Fund
**CCCma** Canadian Centre for Climate Modelling and Analysis
**CCCSN** Canadian Climate Change Scenario Network
**CCEE** Climate Change, Energy and Environment
**CCGS** Canadian Coast Guard Ship
**CCIAP** Climate Change Impacts and Adaptation Program
**C-CIARN** Canadian Climate Impacts and Adaptation Research Network
**CCIS** Climate Change Interim Scenario
**CCIS** Canadian Climate Impacts Scenarios
**CCME** Canadian Council of Ministers for the Environment
**CCNL** Conservation Corps of Newfoundland and Labrador
**CCP** Canadian Carbon Program
**CCRS** Canadian Centre for Remote Sensing
**CCS** Carbon Capture and Storage
**CCSN** Climate Change Scenario Network
**CDAMP** Canadian Drought Alert and Monitoring Program
**CDERA** Carribean Disaster Emergency Response Agency
**CECAB** Canadian Environmental Certification Approval Board
**CED** Clean Energy Dialogue
**CEPA** Canadian Environmental Protection Act
**CER** Certified Emission Reduction
**CESD** Commissioner for Environment and Sustainable Development
**CESEFOR** Centro de Servicios y Promoción Forestal, Spain
**CESI** Canadian Environmental Sustainability Indicators
**CFCAS** Canadian Foundation for Climate and Atmospheric Science
**CFD** Computational Fluid Dynamics
**CFS** Canadian Forest Service, Natural Resources Canada
**CFS** Canadian Forces Station
**CFS-CAT** Canadian Forest Service - Carbon Accounting Team
**CFWIS** Canadian Wildland Fire Information Service
**CGCM** Canadian Global Climate Model
**CH4** Methane
**CHST** Canada Health Transfer and Canada Social Transfer
**CIDA** Canadian International Development Agency
**CIHR** Canadian Institute of Health Research
**CILSS** Permanent Interstate Committee for Drought Control in the Sahel
**CIP** Canadian Institute of Planners
**CIS** Canadian Ice Service
**CKPNR** Canada's Kyoto Protocol National Registry
**CLASS** Canadian Land Surface Scheme
**CLIVAR** Climate Variability and Predictability
**CMC** Canadian Meterological Centre
**CMFN** Canadian Model Forest Network
**CO** Carbon Monoxide
**CO2** Carbon Dioxide
**CONAFOR** Comisión Nacional Forestal, Government of Mexico
**CoP** Conference of the Parties (signatories to the UNFCCC)
**CRCM** Canadian Regional Climate Model
**CRCMD** Canadian Regional Climate Modelling and Diagnostics
**CRF** Common Reporting Format
**CRN** Climate Reference Network, United States
**CRYSYS** Cryosphere System
**CSA** Canadian Space Agency
**CSHD** Climate System History and Dynamics
**CSLF** Carbon Sequestration Leadership Forum
**C-SOLAS** Canadian Surface Ocean Lower Atmosphere Study
**C-SPARC** Canadian-Stratospheric Processes and their Role in Climate
**CTI** Climate Technology Initiative, International Energy Agency
**D**
**DBCP** Data Buoy Cooperation Panel
**DES** Data Exchange Standard
**DfID** Department for International Development, United Kingdom
**DFO** Department of Fisheries and Oceans
**DRI** Drought Research Initiative
**E**
**EC** Environment Canada
**ECO** Environmental Careers Organization
**ecoETI** ecoEnergy Technology Initiative
**ECOSUR** El Colegio de la Frontera Sur, Mexico
**ECV** Essential Climate Variables
**EGGS** Enhancement of Greenhouse Gas Sinks
**EGTT** Expert Group on Technology Transfer
**EMAN** Ecological Monitoring and Assessment Network
**ENGO** Environmental Non-Governmental Organization
**ENSO** El Niño-Southern Oscillation
**EOSD** Earth Observation for Sustainable Development of Forests
**eq.** Equivalent
**ERU** Emission Reduction Unit
**ESA** European Space Agency
**ESD** Education for Sustainable Development
**eTV** ecoTechnology for Vehicles
**F**

**FAO** Food and Agriculture Organization, United Nations
**FCRN** Fluxnet Canada Research Network
**FEC** Forest Ecological Land Classification
**FIGC** Forest Indicators of Global Change
**FTP** File Transfer Protocol
**G**
**GAW** Global Atmosphere Watch
**GBeP** Global Bioenergy Partnership
**GC3M** Global Coupled Carbon Climate Model
**GCCSI** Global Carbon Capture and Storage Institute
**GCM** Global Climate Model
**GCOS** Global Climate Observing System
**GCOS IP** Global Climate Observing System Implementation Plan
**GCW** Global Cryosphere Watch
**GDP** Gross Domestic Product
**GEF** Global Environment Facility
**Gen IV** Generation IV International Forum on Nuclear Power
**GEO** Group on Earch Observations
**GEOSS** Global Earth Observation System of Systems
**GEWEX** Global Energy and Water Cycle Experiment
**GHG** Greenhouse Gas
**GIS** Geographic Information System
**GLOSS** Global Sea Level Observing System
**GOAPP** Global Ocean Atmosphere Prediction and Predictability
**GoC** Government of Canada
**GOFC-GOLD** Global Observation of Forest and Land Cover Dynamics
**GOOS** Global Ocean Observing System
**GPS** Global Positioning System
**GSC** Geological Survey of Canada
**GSN** Global Surface Network
**GST** Goods and Services Tax
**GTN-G** Global Terrestrial Network for Glaciers
**GTN-P** Global Terrestrial Network for Permafrost
**GTN-R** Global Terrestrial Network for Rivers
**GTOS** Global Terrestrial Observing System
**GUAN** GCOS Upper Air Network
**H**
**HC** Health Canada
**HDD** Heating Degree Day
**HDDV** Heavy-Duty Diesel Vehicle
**HFC** Hydrofluorocarbon
**HST** Harmonized Sales Tax
**HYDAT** Hydroclimatological Data Retrieval Program
**I**
**ICAO** International Civil Aviation Organization
**ICARP** International Conference on Arctic Research Planning
**IDRC** International Development and Research Centre
**IEA** International Energy Agency
**IGACO** International Global Atmospheric Chemistry Observations
**IGBP** International Geosphere-Biosphere Programme
**IGCC** Integrated Gasification Combined Cycle
**IGFA** International Group of Funding Agencies for Global Change Research
**IGOL** Integrated Global Observing Strategy Partnership
**IHP** International Hydrological Programme
**IMFN** International Model Forest Global Forum
**IML** L'institue Maurice Lamontagne
**IMO** International Maritime Organization
**INAC** Indian and Northern Affairs Canada
**IOC** Intergovernmental Oceanographic Commission
**IP3** Improved Processes and Parameterisation for Prediction in Cold Regions
**IPA** International Permafrost Association
**IPCC** Intergovernmental Panel on Climate Change
**IPEEC** International Partnership on Energy Efficiency Cooperation
**IPY** International Polar Year
**IR** Infrared
**IRIS** Integrated Regional Impact Studies
**ISDM** Integrated Science Data Management
**ISO** International Organization for Standardization
**ISTP** International Science and Technology Partnerships Inc.
**IT** Information Technology
**ITEX** International Tundra Experiment
**ITG** Inter-commission Task Group
**ITL** International Transaction Log
**J**
**JAXA** Japan Aerospace Exploration Agency
**JCOMM** Joint Technical Commission for Oceanography and Marine Meteorology
**K**
**KHPS** Kinetic Hydropower System
**KPIA** Kyoto Protocol Implementation Act
**L**
**LCCoP** Land Cover Community of Practice
**ICER** Long-Term Certified Emission Reduction
**LDC** Lesser-Developed Country
**LDGT** Light-Duty Gasoline Truck
**LDGV** Light-Duty Gasoline Vehicle
**LEC** Local Environmental Coordinator
**LULUCF** Land Use, Land-Use Change and Forestry
**M**
**MAGS** Mackenzie GEWEX Study
**MDIP** Market Development Incentive Payments
**MFERD** Magnesium Front End Research and Development Project
**Micro CHP** Micro Combined Heat and Power
**MOC2** Modelling of Clouds and Climate Network
**MOPITT** Measurements of Pollution in the Troposphere
**MOST** Moving on Sustainable Transportation
**MOU** Memorandum of Understanding
**MPA** Marine Protected Area
**MSC** Meteorological Service of Canada
**MSW** Municipal Solid Waste
**MTL** Materials Technology Laboratory
**N**
**N** Nitrogen
**N2O** Nitrous Oxide
**NACP** North American Carbon Program
**NAEWG** North American Energy Working Group
**NAFTA** North American Free Trade Agreement
**NAMP** North American Maple Project
**NASA** National Aeronautics and Space Administration, United States
**NCAF** National Carbon Accounting Framework
**NCDC** National Climatic Data Centre, United States
**NCE** Networks of Centres of Excellence
**NCGAVS** National Carbon and Greenhouse Gas Accounting and Verification System
**NDCA** Nickel District Conservation Authority
**NED** Northern Energy Development
**NERIN** Northern Eurasia Regional Information Network
**NFCMARS** National Forest Carbon Monitoring, Accounting and Reporting System
**NFI** National Forest Inventory, new
**NGO** Non-Governmental Organization
**NIR** National Inventory Report
**NIRST** New Infra-Red Sensor Technology
**NIRST** New IR Sensor Technology
**NOAA** National Oceanic and Atmospheric Administration, United States
**NOS** National Occupational Standard
**NRCan** Natural Resources Canada
**NRTEE** National Round Table on the Environment and the Economy
**NSERC** Natural Sciences and Engineering Research Council of Canada
**NSIDC** National Snow and Ice Data Centre

**NWP** Nairobi Work Program
**NWRI** National Water Research Institute
**NZEH** Net-Zero Energy Home
**O**
**O** Oxygen
**OAP** Ocean Action Plan
**ODA** Official Development Assistance
**ODS** Ozone-Depleting Substance
**OECD** Organization for Economic Cooperation and Development
**OEE** Office of Energy Efficiency, Natural Resources Canada
**OGD** Other Governmental Department
**OSFAC** Observatoire Satellital des Forêts d'Afrique Centrale
**OSIRIS** Optical Spectrograph and InfraRed Imaging System
**OSP** Ocean Station Papa
**OSTP** Office of Science and Technology Policy, United States
**P**
**P** Phosphorus
**PAM** Policies and Measures
**PAME** Protection of the Arctic Marine Environment
**PCMDI** Program for Climate Model Diagnosis and Intercomparison
**PCO** Privy Council Office
**PCW** Polar Communications and Weather
**PEARL** Polar Environment Atmospheric Research Laboratory
**PEI** Prince Edward Island
**PERD** Program of Energy Research and Development
**PFAN** Private Financing Advisory Network
**PFC** Perfluorocarbon
**PHAC** Public Health Agency of Canada
**PIEVC** Public Infrastructure Engineering Vulnerability Committee
**PMO** Prime Minister's Office
**PPCR** Pilot Program for Climate Resilience, World Bank
**Q**
**QA** Quality Assurance
**QC** Quality Control
**R**
**R&D** Research & Development
**RAC** Regional Adaptation Collaborative
**RAICC** Rapid Assessment of the Impacts of Climate Change
**RAID** Redundant Array of Independent Disks
**RCE** Regional Centres of Expertise, United Nations
**RCM** RADARSAT Constellation Mission
**RCM** Regional Climate Model
**RCS** Reference Climate Station
**REDD** Reducing Emissions from Deforestation and Degradation
**RedLatif** Red Latinoamericana de Teledetección e Incendios Forestales
**REEEP** Renewable Energy & Energy Efficiency Partnership
**RGGI** Regional Greenhouse Gas Initiative
**RMU** Removal Unit
**RNODC** Responsible National Oceanographic Data Centre
**ROSHYDROMET** Russian Institute of Meteorology and Hydrology
**S** Sulphur
**S&T** Science & Technology
**SADC** South African Development Community
**SAFNET** Southern Africa Regional Fire Network
**SAGES** Sustainable Agriculture Environmental Systems
**SAN** Storage Area Network
**SAR** Synthetic Aperture Radar
**SBSTA** Subsidiary Body for Scientific and Technological Advice, UNFCCC
**SCCF** Special Climate Change Fund
**SDS** Sustainable Development Strategy
**SDSM** Statistical Downscaling Model
**SEARRIN** Southeast Asia Regional Research Information Network
**SF6** Sulphur Hexafluoride
**SFU** Simon Fraser University, British Columbia
**Si** Silicon
**SIS** Small Island State
**SMART** System of Measurement and Reporting for Technologies
**SOLAS** Surface Ocean Lower Atmosphere Study
**SOT** Ship Observations Team
**SPARC** Stratospheric Processes and their Role in Climate
**SSHRC** Social Sciences and Humanities Research Council of Canada
**SSL** Secure Socket Layer
**STAR** Storm Studies in the Arctic
**SUV** Sport Utility Vehicle
**SWCR** Supercritical Water-Cooled Reactor
**SWE** Snow Cover Fraction and Water Equivalent
**SWIFT** Stratosphere Wind Interferometer for Transport Studies
**SWX** Surface Weather
**T**
**TBS** Treasury Board of Canada Secretariat
**TC** Transport Canada
**TEAM** Technology Early Action Measures
**TNA** Technology Needs Assessments
**U**
**UK** United Kingdom
**UN** United Nations
**UNDP** United Nations Development Programme
**UNEP** United Nations Environment Program
**UNESCO** United Nations Educational, Scientific and Cultural Organization
**UNFCCC** United Nations Framework Convention on Climate Change
**UOG** Upstream Oil and Gas
**UPS** Uninterruptable Power Supply
**US** United States of America
**USGS** United States Geological Survey
**V**
**VHTR** Very-High Temperature Reactor
**VLH** Very Low Head
**VOSClim** Voluntary Observing Ship Climate Project
**VPC** Verdant Power Canada
**VPN** Virtual Private Network
**W**
**WARN** West Africa Regional Network
**W-CIRC** Water and Climate Impact Research Centre
**WCRP** World Climate Research Programme
**WGCV** Working Group of Calibration and Validation
**WGMS** World Glacier Monitoring Service
**WMO** World Meteorological Organization

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